IX

THE

STRINGS

GENERAL CONSIDERATIONS

The acoustics of a vibrating string were partially discussed in Chapter I. It should be further noted here that the pitch of a string is a function not only of its length but of its tension (direct relationship) and mass (inverse relationship).

ACOUSTICS

Even the most massive string presents so little surface to the air that its tone is extremely soft. In order to bring it up to audible levels the string is either amplified electronically, or, more usually, coupled acoustically to a thin, flat **soundboard**. In the harp the strings are in direct contact with the soundboard, but in virtually every other non-electric string instrument each string passes over a narrow **bridge** at one or both ends before its point of attachment. The string is pressed firmly against the bridge, which picks up the string's vibrations and transmits them to the soundboard on which it stands.

The soundboard has several hundred times the surface area of the strings to which it is coupled, and is thus capable of transmitting the sound to the air much more efficiently than the strings themselves. To achieve even more amplification the soundboard usually forms one wall of a complete wooden box, whose cavity defines an enclosed air space capable of vibrating in sympathy with the soundboard. The enclosed air communicates with the outside air via one or more holes in the box.

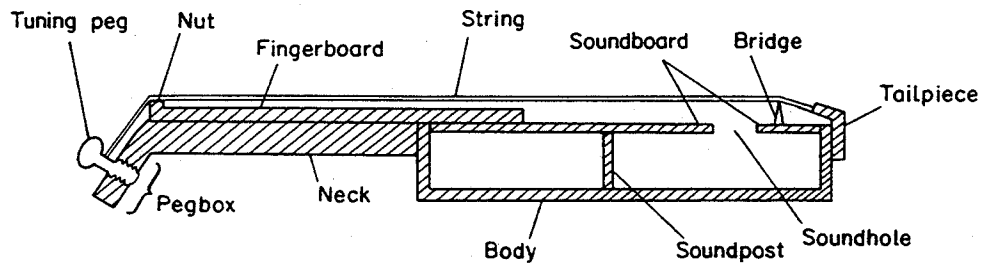


FIGURE 198. *Diagrammatic sagittal section of a string instrument with fingerboard.*

A string may be set vibrating by striking (cimbalom), plucking (guitar), or bowing (violin); only bowing provides a sustained sound. The tone quality may be varied by activating the string near its middle, at one end, or somewhere in between; this is discussed in more detail under the separate headings for individual instruments.

The strings of a string instrument may be made of metal, gut (made from the outer intestinal lining of sheep, not cats), or nylon. The mass of a low string is increased by a **winding** of fine wire around the central core.

The strings of each instrument are tuned to specific, standard pitches, but unorthodox tunings (called **scordatura**) can be used. Typically, scordatura for any string may run up to a major second above the standard tuning or a perfect fourth below it without seriously affecting the timbre of the instrument. This is least problematic and most effective with gut strings. Scordatura cannot be imposed more than a second above the standard tuning without risk of snapping the string, but a gut string may be dropped as much as an octave for special effects. Extreme lowering of this sort produces an increasingly muffled tone quality, decreased sustention of tone, and lowered dynamic range. A very slack string is quite likely to rattle against adjacent strings, the soundboard, or the fingerboard, especially at high dynamic levels. (The possibilities of scordatura are not reckoned in the ranges given for the instruments in the vital-statistics charts.)

PERFORMANCE CHARACTERISTICS

In the harp, the cimbalom, and the string keyboards there is a separate string for each note, but in the guitar and violin families the strings are few in number and run along a **fingerboard** at the far end of which the tuning pegs are located. The **pegboard** or **pegbox** is set at a slight angle to the fingerboard so that the strings are automatically pressed down against the far end (the **nut**) of the fingerboard (see Fig. 198). By pressing the string firmly against the fingerboard with a finger of the left hand, the player can shorten its vibrating length, thus raising its pitch by any desired amount.

The left thumb is usually held at the back of the instrument's neck and is thus not ordinarily involved in this **stopping** of the strings. For indicating fingerings the remaining fingers are numbered one to four, starting with the index. Figure 199 shows how, by using only the few available strings tuned in fourths or fifths, these four fingers can play all the notes in the range of several octaves without shifting the position of the hand along the neck. Note that on small (high-pitched) instruments such as the violin or mandolin the relationship between fingerings

Pitch of Open String

Finger	g⁰	d¹	a¹	e²
0				
1	a♭⁰, a⁰	e♭¹, e¹	b♭¹, b¹	f², f♯²
2	a⁰, b♭⁰, b⁰	e¹, f¹, f♯¹	b¹, c², c♯²	g♭², g², g♯²
3	b⁰, c¹, c♯¹	g♭¹, g¹, g♯¹	d♭², d², d♯²	a♭², a², a♯²
4	d♭¹, d¹, d♯¹	a♭¹, a¹, a♯¹	e♭², e², e♯²	b♭², b², b♯²

VIOLIN

Pitch of Open String

Finger	E₀	A₀	d⁰	g⁰	b⁰	e¹
0						
1	F₀	B♭₀	e♭⁰	g♯⁰	c¹	f¹
2	F♯₀	B₀	e⁰	a⁰	c♯¹	f♯¹
3	G₀	c⁰	f⁰	b♭⁰	d¹	g¹
4	G♯₀	c♯⁰	f♯⁰	b⁰	e♭¹	g♯¹

GUITAR

FIGURE 199. *Fingerings for notes in first position on the violin and guitar.*

and notes is essentially diatonic, while on larger (lower) instruments such as the guitar or cello the relationship is chromatic.

Of course, the hand can be shifted up the neck, transposing the whole pattern upward by various intervals. Each discrete unit of distance shifted is numbered as a **position**, that closest to the nut being **first position**—shown in Figure 199. Shifting up a step would put the hand in **second position**, up two steps **third position**, and so on. The key to good string-writing is to keep the notes as much as possible "under the hand," i.e., within the range reachable by the fingers without shifting, and where shifts must be made to keep them generally small. Where large shifts must be made the music cannot move with quite as much agility, though so high are current playing standards, particularly on the violin, that feats of great virtuosity are frequently achieved.

The amount by which a string's sounding length must be shortened to produce a given rise in pitch is a function of the length of the string, and as one goes higher and higher on the string the distance between adjacent scale steps becomes shorter and shorter. This can be seen clearly in the arrangement of frets on the neck of a guitar. As an example consider a rise in pitch of one octave. This requires reducing the sounding length of the string by one-half, and accordingly the player's finger must be put down exactly in the middle of the string. To rise another octave half the *remaining* length must be removed, i.e., only *one-quarter* of the whole, and jumping yet a third octave would require shortening the string by only another eighth. Theoretically, then, one could produce infinitely high pitches by using increasingly small lengths of string; in practice, however, the limit is determined by the shortest length at which the string will vibrate.

The practical significance of all this is that the higher one goes on a string the greater the pitch interval across which one's fingers can reach without shifting. But since the individual pitches are closer together high on the string, it is more difficult to play strictly in tune up there; this is particularly a problem on the violin.

It will be noticed that, unlike wind instruments, strings do not make use of upper partials to extend the range but use the first partial exclusively. This makes their timbre much more uniform throughout their range than that of a wind instrument. Only the open-string notes stand out, for these are slightly more brilliant and robust than stopped notes. Isolated upper partials can be obtained from a string, but these are used strictly as a special timbral effect, not as a range extension. These **harmonics** are obtained by *lightly* touching a node of the appro-

priate partial. Harmonics of an open string are called **natural harmonics** and those produced from a stopped note are called **artificial**.

On instruments of the guitar or violin type, the position of the nodes can be described in terms of the pitch that would be produced if the string were stopped, rather than lightly touched, at that point. The relationship among fundamental pitch, node position, and harmonic produced is shown in Figure 200. Note that there are two graded series of nodes—one approaching the nut, the other approaching the bridge and corresponding in position to the spots where the same pitches would be produced by stopping as fundamentals. Between these the higher partials have a number of additional nodes which are, however, seldom used.

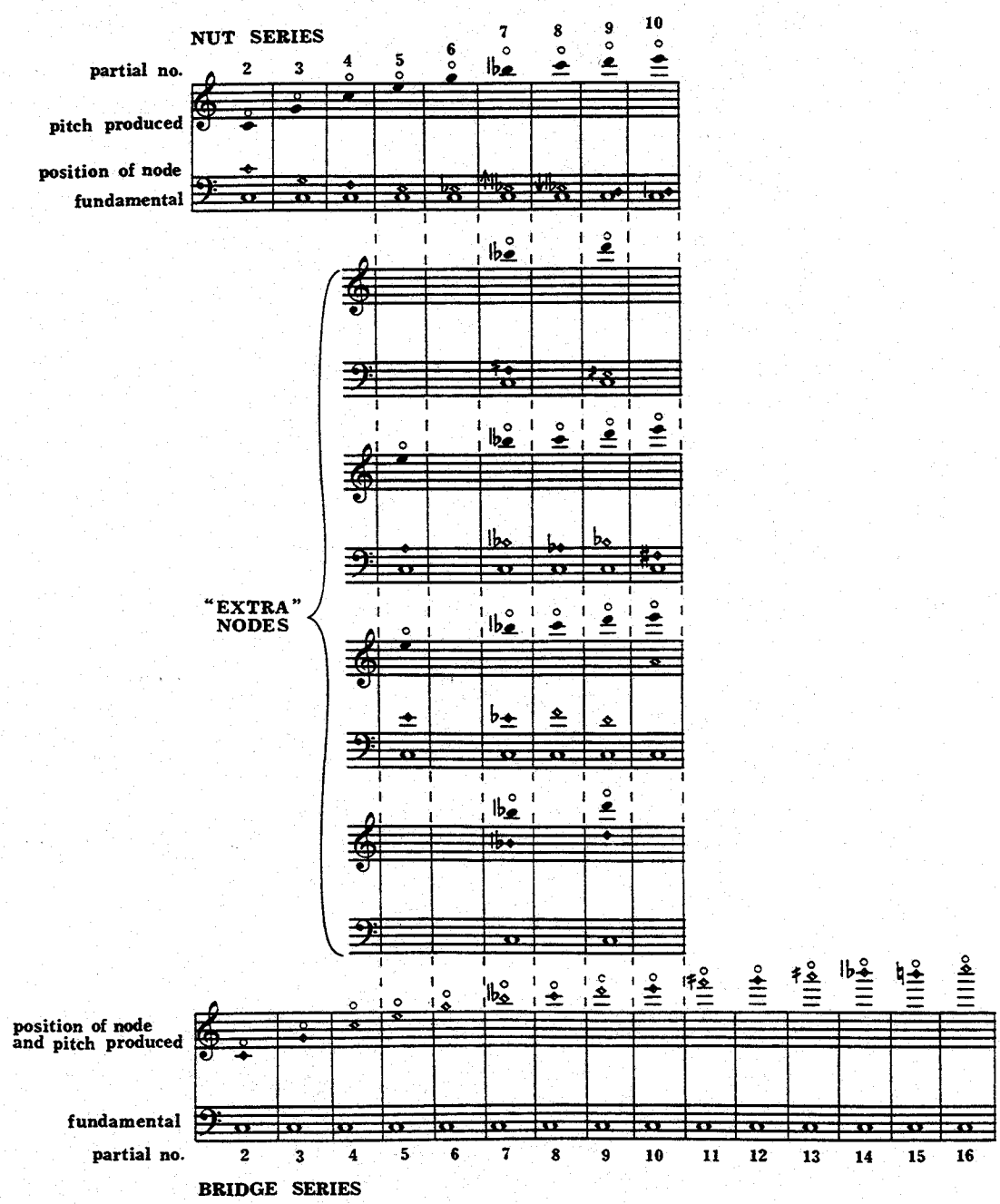


FIGURE 200. *Harmonics* theoretically *generatable from the note* c^0.

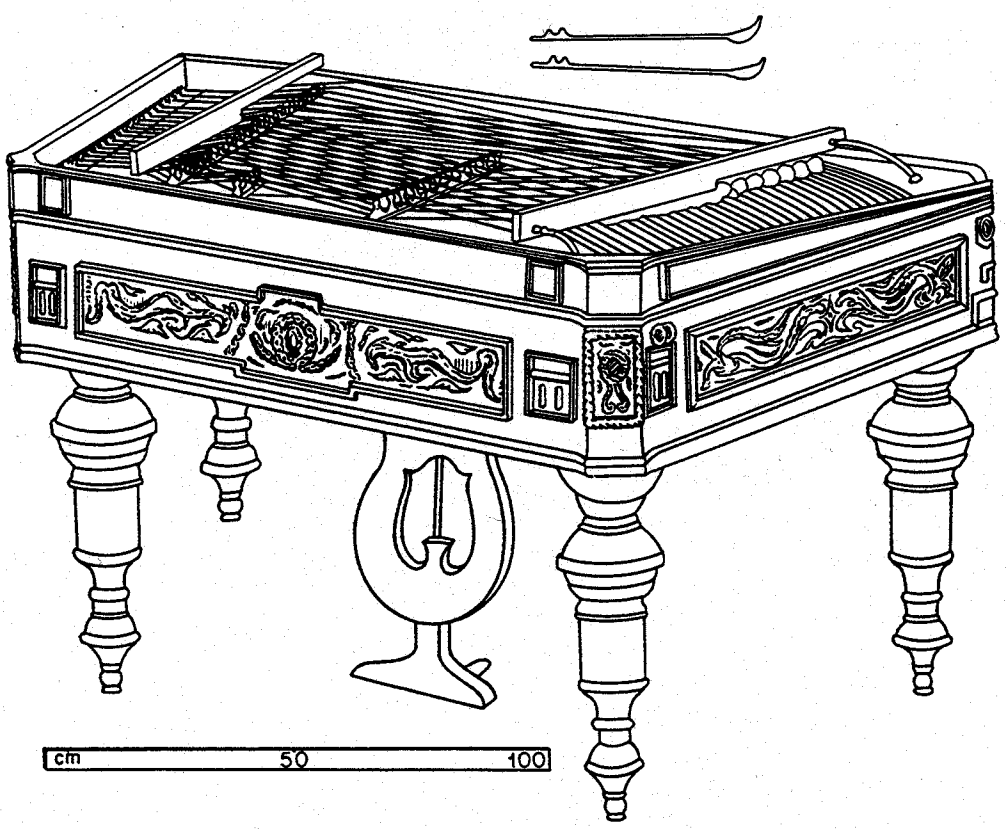


FIGURE 201. *The cimbalom and its beaters.*

THE CIMBALOM

The cimbalom is a Hungarian popular instrument that is extremely rare in North America and would find no place in this book had it not been used in two major works by Stravinsky and in a variety of other compositions, mostly Eastern European.

It belongs to the large group of instruments known as **zithers**, in which there are numerous strings running across a large soundboard and which have no neck—the piano and harpsichord are also zithers. Zithers in which the strings are struck with mallets are called **dulcimers**, and the cimbalom is a highly developed dulcimer with a large range and a sustain pedal.

Except for the optional low D_0 and C_0, every note on the cimbalom is at least triple-strung. The higher notes may be quadruple- or even quintuple-strung.

In order to preserve a compact layout and yet keep the pitches clearly enough separated for accurate play, the strings are run across a complex system of five bridges (Fig. 203). Some of the strings passing each bridge run over it in the normal way, while others pass *under* it and are thus inaccessible to the player at that point. By running alternate courses (a **course** is any set of strings running closely adjacent to each other and meant to be played simultaneously) over alternate bridges, the player is given access to neighboring pitches on alternate sides of the instrument. The reader can visualize how this works by interlacing the fingers of his/her hands and looking at them from above.

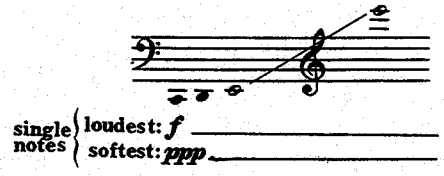
name of instrument	*abbreviations*	*written range*	*sounds*	*availability*
cimbalom	cimb.		as written	very rare

FIGURE 202. *The cimbalom—vital statistics.*

In the upper part of the instrument's range a single course may produce as many as three different notes by being strung over several bridges. For instance, the highest (rearmost) course runs from the hitchpins on the left up to the center-left bridge, producing $a\flat^2$, then across to the center-right bridge, making $b\flat^2$, and finally from there down to the tuning pins on the right, giving e^3. The second course starts with a brief unused portion rising from the hitchpins to the left bridge; the course then passes to the left-center bridge, giving c^3, but it is strung *beneath* this bridge and beneath the center-right bridge as well, so the portion between these bridges is also unused. The course then rises from the right-center bridge to the right one, giving $e\flat^3$, and from there is attached to the tuning pegs.

Except for the notes just mentioned and the note $b\flat^2$, the strings are not actually held down by the bridge(s) they pass beneath; rather, they run freely through a hole in the bridge, which therefore does not demarcate their sounding length. The sixth course, for example, runs straight from the hitchpins up to the right bridge, bypassing the center-left bridge and giving only the single note $e\flat^1$.

It will be noted that this method of stringing produces a rather disorderly arrangement of pitches, particularly in the upper part of the range.

The cimbalom is capable of agility equaling or surpassing that of any mallet instrument, to which it is similar in technique. It is played with a pair of special sticks that are somewhat shorter and lighter than rubber-series mallets. Each stick is held between the thumb and middle finger and steadied above by the index finger. The heads of the sticks are long and thin, enabling the player to strike two adjacent courses simultaneously. The interlacing of the courses results in different tones being adjacent at different places along each single course; thus, by striking in one or another place $e\flat^1$ (for instance) can be made to sound simultaneously with $e\flat^2$, d^3, $d\flat^1$, g^2, or $b\flat^1$. Since there are two sticks, a large variety of three- and four-note chords are available by this means. Multi-mallet playing *may* be possible but does not appear to have been attempted. The traditional grip for cimbalom sticks plus the fact that the instrument is usually played sitting down may make multi-mallet playing difficult or unrewarding.

Both wound and unwound sticks are available, the wound ones being usual. An additional timbre variation can be achieved by striking very near the bridge. This produces a snarly, spitting tone rich in upper partials and is designated by the term **sul ponticello**, also used for other string instruments. This term may if necessary be abbreviated to "pont."; it is canceled by the expression "ord." or "nat."

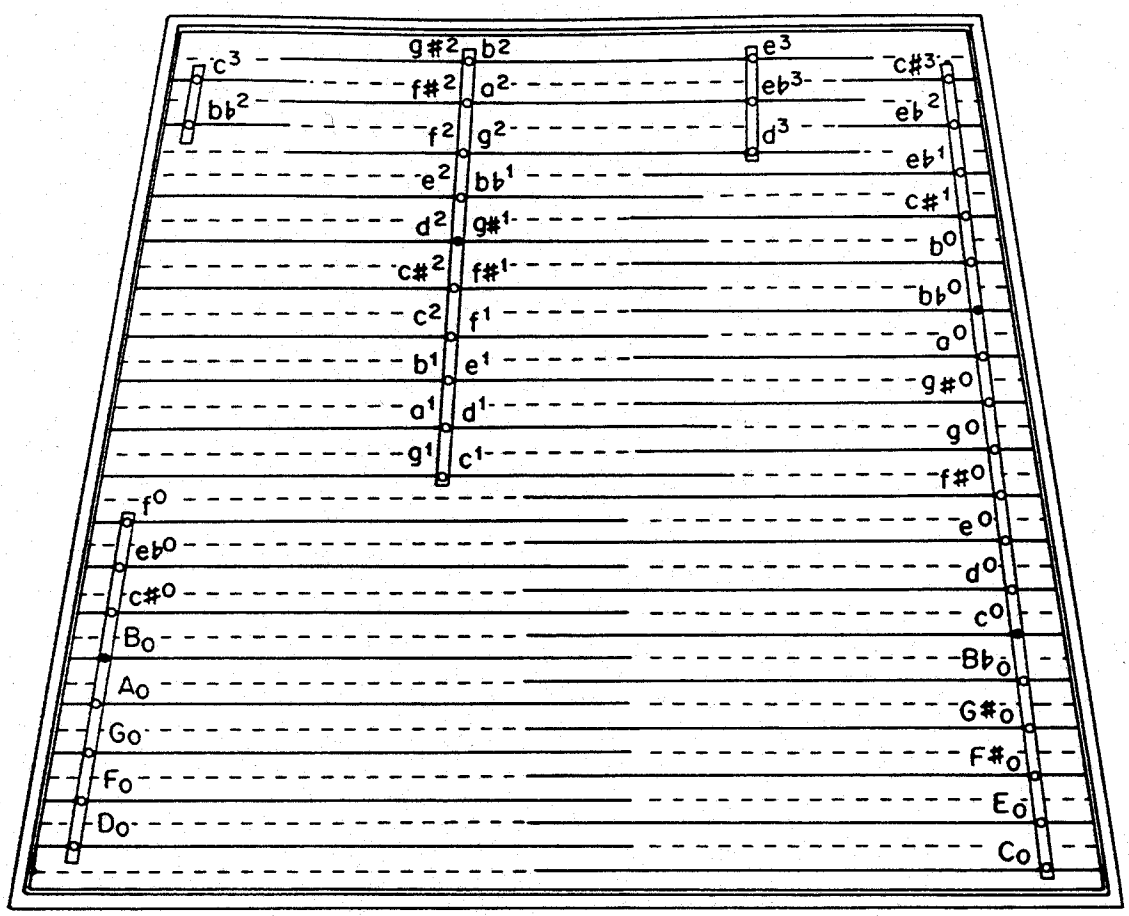


FIGURE 203. *Layout of pitches on the cimbalom.*

The tone of the cimbalom is bright and harpsichord-like, with a distinctive pinging attack. The sustaining power of the instrument is intermediate between marimba and harpsichord. The sustain pedal functions and is used identically to that of the vibraphone. The damper bars do not affect the notes $e\flat^2$, g^2, a^2, $b\flat^2$, b^2, c^3, $c\sharp^3$, and $e\flat^3$.

Cimbalom music may be notated on one or two staves, whichever is clearer and more convenient.

Musical Examples

CIMBALOM:

Stravinsky, *Renard*
Boulez, *Eclat*

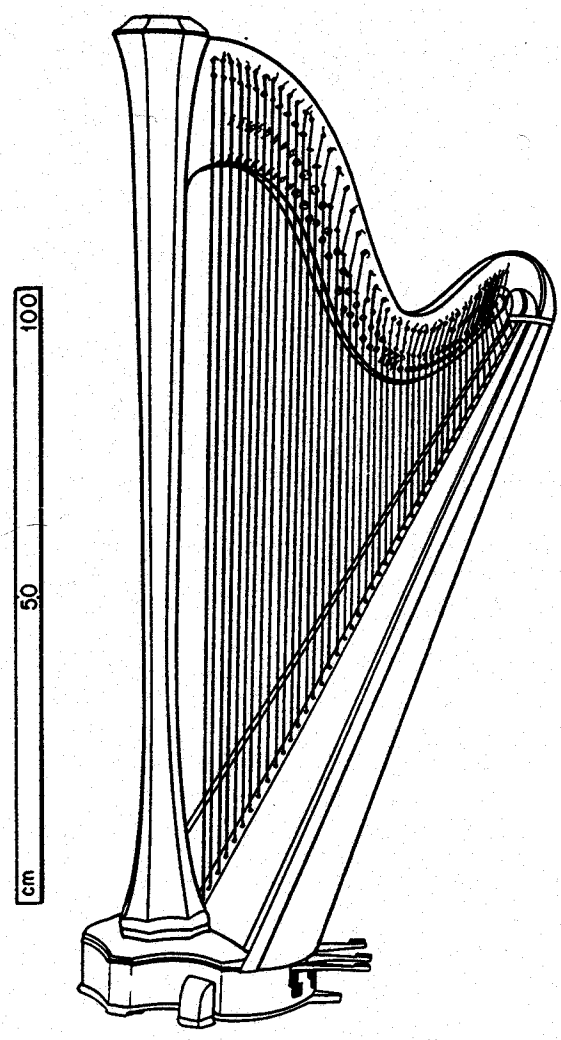


FIGURE 204. *The harp.*

THE HARP

The harp is unique in that it is strung perpendicular to the soundboard. As may well be imagined, this arrangement is very inefficient acoustically, and the harp is thus the softest of all the standard orchestral instruments. It compares well in volume with such instruments as the harpsichord, acoustic guitar, and bass flute, and must be scored carefully when combined with anything louder—even a light voice or a violin.

THE PEDALS

The strings of the harp are tuned diatonically, i.e., seven strings in each octave. Chromatic tones are obtained with a mechanical stopping action controlled by seven pedals (Fig. 205). Each pedal governs an entire pitch-class, so that the pedal furthest to the left controls all the D

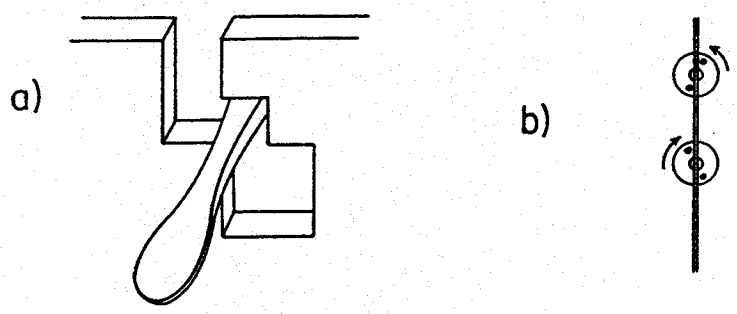


FIGURE 205. *Details of harp mechanism: (a) a pedal; (b) string with forks.*

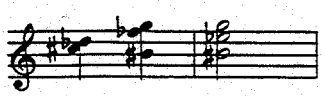
strings, the second from the left all the C strings, and so on (from left to right the order is D, C, B, E, F, G, A). Each pedal moves in a stepped slot, the steps enabling the pedal to be left in any of three positions. In the uppermost position all notes in the pitch-class governed by the pedal will be flat, in the middle position they will be natural, and in the lower position they will be sharp.

Each string is provided with a pair of rotating disks (mounted on the "neck" at the top of the harp), each with two prongs. The string is tuned to the flatted note; when the pedal is depressed to the middle position the upper **fork** rotates just enough so that its prongs firmly stop the string, shortening its length and raising its pitch a half-step to the natural position. When the pedal is depressed further, the lower fork also rotates and the string is raised another half-step.

Note that all the strings are tuned to give flat notes: that is why the harp is often described as being tuned "to the key of C♭ major." This is just a technical detail, however; it is best to think of the harp as tuned to the "white key" notes of the keyboard, the pedals giving flat notes when raised and sharp ones when depressed. The low C_1 and D_1 strings are not provided with forks and are thus unaffected by the C and D pedals. On some harps the high g^4 is also unalterable. These strings can be tuned sharp or flat in advance, but if this is done they must of course remain that way throughout the piece. Though such special tunings of these strings are not at all unusual or unorthodox the player should be forewarned whenever they will be required.

The three left-hand pedals are operated by the left foot, the four right-hand ones by the right foot. The middle (E) pedal may if necessary be taken by the left foot, and that foot may even reach over to the F pedal in a pinch (though this is clumsy), while the right foot can make a similarly awkward reach over to the B pedal. In an emergency, one foot can shift two pedals simultaneously; the foot must be turned sideways to do this and the two pedals so moved must both end in the same position—both flat, both natural, or both sharp.

The spelling of all notes and chords in a harp part should reflect the way they are played, even when this results in illogical-looking formulations such as the following:



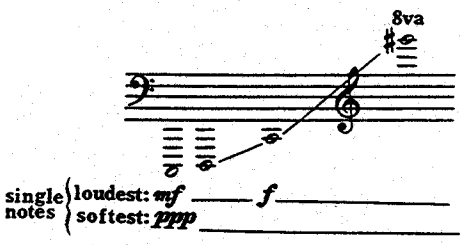
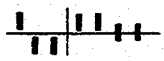
name of instrument	*abbreviations*	*written range*	*sounds*	*availability*
harp	hp.		as written	usually available

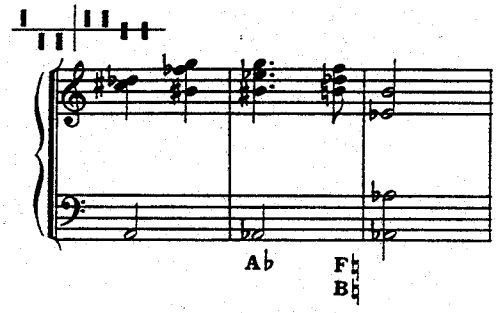
FIGURE 206. *The harp—vital statistics.*

At the beginning of a piece and at each subsequent major change in the configuration of the pedals, the complete configuration should be given. The best way to do so is by means of a diagram like this:



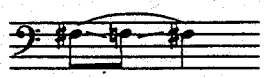
This is a schematic representation of the actual positions of the pedals; pedals shown on the horizontal line are in the natural position, those above it are flat, and those below it are sharp. The pedals are indicated left to right just as they appear on the harp, and the vertical line divides the three left pedals from the four right ones. As given, then, our diagram indicates the disposition D♭, C♯, B♯, E♭, F♭, G♮, A♮, the one needed to play the passage shown above. An older notation would be simply to list the pitches by name as we have just done, but the schematic diagram is much more compact and, for a harpist, more quickly and easily read.

Whenever an individual pedal or two must be shifted during the course of a piece, the new pitch should be given below the double staff, as below. When two pedals must be shifted simultaneously, the right-hand pedal should be notated above the left-hand one, as in the example.



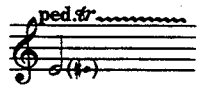
The pedals can be operated swiftly and silently, but highly chromatic music is not idiomatic for the harp. A part like the one in Schoenberg's *Herzgewächse*, while it is possible to play and even musically effective, is not written so much for the harp as in spite of it.

It is not traditional on the harp to shift the pitch of a string while it is vibrating, but the effect has become quite common of late. It should be notated as a portamento, thus:



but it must be emphasized that the sound produced is not a portamento but a simple slur.

It is even possible to make a half-step trill with a pedal; such trills should be carefully distinguished from ordinary ones by some special notation, since harp trills are usually performed by alternately plucking adjacent strings. There is no standard notation, but the following will be instantly understood and is recommended:



FINGERING AND ARTICULATION

Harp music is notated on two staves, just like piano music, and, as with piano music, notes for the right hand are placed on the upper staff, notes for the left hand on the lower staff (with exceptions as noted on p. 259). The instrument rests on the player's right shoulder and the hands pluck the strings from opposite sides so that either hand can play in any part of the range at any time without getting tangled up with the other. Because the instrument is placed slightly to the right the two hands approach the strings at different angles, the left reaching straight forward while the right is bent fairly sharply at both elbow and wrist. This difference leads to differences in playing technique in certain situations. It is awkward for the right hand to reach the bass strings, and below G_0 it should be assigned nothing more elaborate than isolated single tones.

Traditionally, neither little finger is used because they are too short to reach the strings when the hands are held in their normal positions. But if the hand is twisted around a bit the little finger *can* be used, and harpists now increasingly are using the fifth fingers in certain passages that are simplified thereby. The use of these fingers will always remain exceptional and specialized, however, and composers, unless they are very familiar with the vagaries of harp fingering, should leave the details of their use up to the player. It is worth bearing in mind, however, that it is possible for one hand to play five notes at a time, provided they are all on adjacent strings.

The chart below shows average maximum two-finger stretches for the harp. Scales are fingered ascending (4)3214321 and descending (1)2341234 in either hand.

Stretch From Finger

To Finger	1	2	3
4	12th	8ve	7th
3	11th	7th	
2	9th		

The maximum duration of a harp tone is about half a second at the top of the range, three seconds in the middle, and six seconds at the bottom. All notes are normally allowed to ring on indefinitely, except when followed by a rest or in places where there is a strong drop in dynamic level, marked change of harmony, texture, etc., or (with the exception noted above) when the pitch of a string must be changed with its pedal. There is seldom much need for damping at the top of the harp's range, where the sound is always delightfully clear, crisp,

and brittle, but in the middle and lower registers the overlapping resonances make for an unavoidable muddiness of rhythm and blurring of harmony unless there is frequent damping. All of this is normally left up to the harpist, who at the very least will "clear" the harp of unwanted bass resonances from time to time by damping all the lower strings simultaneously with the flat of one or both hands. Such clearing may be called for specifically by notating the symbol ⊕ above the staff at the appropriate spot; if any notes (in any part of the range) are to ring past that point, this must be explicitly indicated with ties or some other notation.

To produce a staccato, a harpist must damp each note separately, using the index finger of the right hand or the base of the left thumb, a technique known as "**sons étouffés**" (French: "damped tones"). A staccato so produced can be played as fast as sixteenth-notes at ♩ = 92 in either hand (a bit slower for leaping or chordal passages in the right hand).

As a special effect individual strings may be muted by pressing against the string near the neck with fingers of the left hand and playing only with the right, or they may be muffled completely by pressing with fingers, the flat of either hand, or a whole forearm near the middle of the strings. Neither technique is traditional, and both will have to be explained. The following notations are recommended: for muting,  ; for muffling, .

Normally the harp is plucked with the tips of the fingers near the middle of the strings. This gives the full, gentle, but rather colorless tone characteristic of the harp. The tone may be modified in two ways:

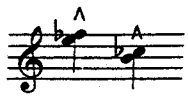
1. By plucking near the soundboard. This makes the instrument sound much like a classical guitar; it is designated by the expression "près de la table" and is canceled by "pos. nat."

2. By plucking with the fingernails, which makes for a rather pingy attack and snarly tone quality. It is designated by the symbol ⌣ placed above the note. If a group of notes are affected, a half-bracket of the appropriate length should follow the symbol, and if a long passage is to be played thus it should be marked " ⌣ (sempre)" and canceled by "nat."

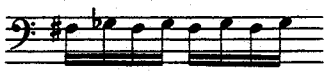
It is usual for all chords on the harp to be slightly arpeggiated, the standard arpeggiation symbol  being used only where a more leisurely effect is intended. If a chord is to be sounded without any arpeggiation at all, a bracket should be placed by it, thus:  .

The harp's glissando—actually a rip and so notated—is performed by drawing a finger across the row of strings. The thumb is normally used for descending glissandos, the index finger for ascending ones, but for a glissando with the fingernail this pattern is reversed. Multiple glissandos can be performed with up to three fingers of each hand ascending and four descending (with fingernails, one ascending and three descending). It is possible, though unorthodox, for a finger or thumb of the same hand to trail lightly behind the glissando, damping each note immediately as it is played. If this effect is desired it must be specified verbally.

A venerable technique, now a cliché, involves the maximum use of enharmonic unisons (e.g., E♭ + D♯) in the pedals so that the harp glissando gives out not a complete scale but a pentatonic scale, diminished seventh chord, or dominant ninth chord. Enharmonic unisons are also useful in reinforcing the power of single notes:



and for rapid repetitions of a note:



Tremolos are usually performed by this means, but a single-string tremolo is also possible (by shaking a finger back and forth across the string). This should be notated as a tremolo, while the two-string tremolo should be written as a trill.

SPECIAL EFFECTS

The **tuning key glissando** is an unorthodox effect that produces a genuine glissando rather than a rip. The harp's metal tuning key is held firmly against the string and slid along it; the relatively great mass and hardness of the tuning key effectively stops the string at whatever point it is applied, and sliding it produces a glissando, in the same way that bottleneck technique does on the guitar. Specific pitches can be obtained by marking the affected string with bits of masking tape. The lowest pitch that can be so produced on any string is a whole step above its open (flat) pitch, and to get even this the tuning key must be held in the left hand right up against the sharp fork, for only on that side of the harp is that portion of the string available. The tuning key can also be used to produce microtones, otherwise available only through scordatura.

Application of the tuning key shortens the decay time of a string by a factor of one-half, so glissandos must be rapid. The highest pitch obtainable (and it can be gotten even from the lowest bass strings) is about g^4. Nonetheless, the highest string on which a glissando is practicable is the g^3 string. Above this the tuning key may still be placed against the middle of the string (though it cannot effectively be slid), and when so placed it produces a note an octave higher than usual, thus extending the harp's compass up to a surprising g^5. Notes so produced decay extremely rapidly.

A tuning key glissando can be produced on two adjacent strings at once by sticking the key between them at an angle, so that both are stopped. The key can also be rattled back and forth between a pair of strings, which will alternate stopped and open pitches. This should be notated as a trill between the two open strings, with the stopped pitches given as small note-heads in parentheses and an instruction such as "trill with tuning key."

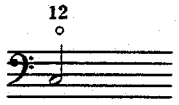
Note that the action of applying the tuning key to a string effectively stops that string to the appropriate pitch; the stopping forks, which lie above the tuning key, will have no effect as long as the key is in contact with the string. If, on the other hand, the tuning key is applied to the string below the point where it is plucked, the forks will retain their usual power, but the sound will be a faint, disembodied *ppp*, since the key will separate the vibrations of the string from the soundboard.

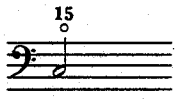
Foremost and most traditional of special effects on the harp are **harmonics**. In ordinary practice these are produced one-handed, on the second partial only, and notated with the usual small circle above the *fundamental* pitch (not the pitch of the harmonic), thus sound-

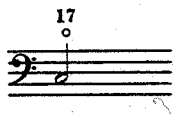
ing an octave higher than written. In the right hand the string is plucked by the thumb while the side of the index finger touches the node; in the left hand the string is also usually plucked by the thumb, but the node is touched by the opposite edge of the hand itself. While only one harmonic at a time is possible for the right hand, up to three at a time (within the range of a sixth) or even, uncomfortably, four (on adjacent strings) can be produced with the left.

The sound of the harmonics is softer than usual, distant, ethereal, and impersonal. Harmonics are weak and somewhat tricky on the wound bass strings (G_0 and lower), and on the lowest two strings they can only be produced two-handed (i.e., touching the node with one hand while plucking with the other)—a technique so unorthodox it must be explained to the player. The highest possible harmonic is d^4, played on the d^3 string.

The third, fourth, and fifth partials can be obtained as harmonics (up to the f^2, c^1, and c^0 strings, respectively), but they are not traditional and must be explained. The following notation is recommended:

third partial: 

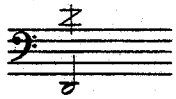
fourth partial: 

fifth partial: 

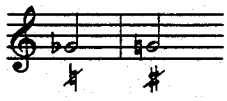
These higher partials are even more denatured in tone than the second, and in the bottom octave all fifth-partial harmonics must be taken two-handed. The third and fifth partials can be used as transposing devices to produce pitches that would otherwise be obtainable only by moving the pedals. It is possible by this means, for instance, to produce a chromatic scale without moving the pedals, or an "impossible" chromatic tone cluster.

Other special effects on the harp include:

1. Plucking a string in the plane of the harp so that (in *forte*) it rattles against its neighbors. This can be done up to $c\sharp^1$ and is notated thus:



2. A very similar effect can be produced up to g^2 by holding a pedal halfway between two positions so that the affected strings rattle against the prongs of the half-engaged fork. Recommended notation:



3. Yet another buzz can be produced by holding the tuning key (less reliably, a fingernail) right next to the string.
4. Plucking the harp with a guitar pick or other plectrum.
5. Striking the strings with a snare stick or knitting needle or flicking them with a fingernail. With the stick or knitting needle a trill can be produced by inserting the stick between

two strings and rattling it back and forth. Tone clusters up to a tenth in width can be produced by slapping the strings (not in the top octave) with the flat of the hand, and an octave-wide tone cluster glissando can be created by sliding the hand across the strings.

6. A whistling or tearing sound produced by sliding the fingers or fingernails along the length of one of the wound bass strings.
7. A vibrato produced by pressing repeatedly against the top of the string with the left thumb while playing normally with the right hand. In the two octaves above c^1 bent tones of as much as a half-step can be produced by this means.
8. Preparing the harp by threading it with a ribbon or strip of paper (see the Crumb example cited below).
9. Tapping the soundboard with fingertips, knuckles, fingernails, or a marimba stick; striking with the tuning key (or other object) the metal plate that covers the right side of the neck; or rattling about in the soundhole or along the row of tuning pegs.
10. Making a subdued racket with the pedals. This last is more a theatrical than a musical effect, since it makes the player look like the recipient of a double hotfoot.

Musical Examples

HARP:

Falla, *Psyché*
Chavez, *Sinfonia de Antigona*
Varèse, *Offrandes*
Berio, *Sequenza II*
Crumb, *Ancient Voices of Children*

ACOUSTIC GUITARS

The term "plucked strings" does not usually include either the harp or the harpsichord, but is used only with reference to those plucked-string instruments that also have a distinct neck and fingerboard.

Of the many varieties in general use in North America all but the banjo, ukulele, and mandolin are called guitars. The large and varied guitar family can be divided into acoustic versus electric types.

The three important varieties of acoustic guitar are very similar in construction and technique; they have differing timbres, however, and are used for differing musical purposes. All have six courses, tuned as given in Figure 208, and a fingerboard inlaid with raised **frets** that aid the player in producing stopped notes securely and accurately, and give these notes much of the resonant fullness of open-string notes.

The **classical guitar** has nylon strings, giving it a delicate, refined tone. The body intersects the neck at the twelfth fret. The term "guitar," unmodified, refers to this instrument in any classical-music context.

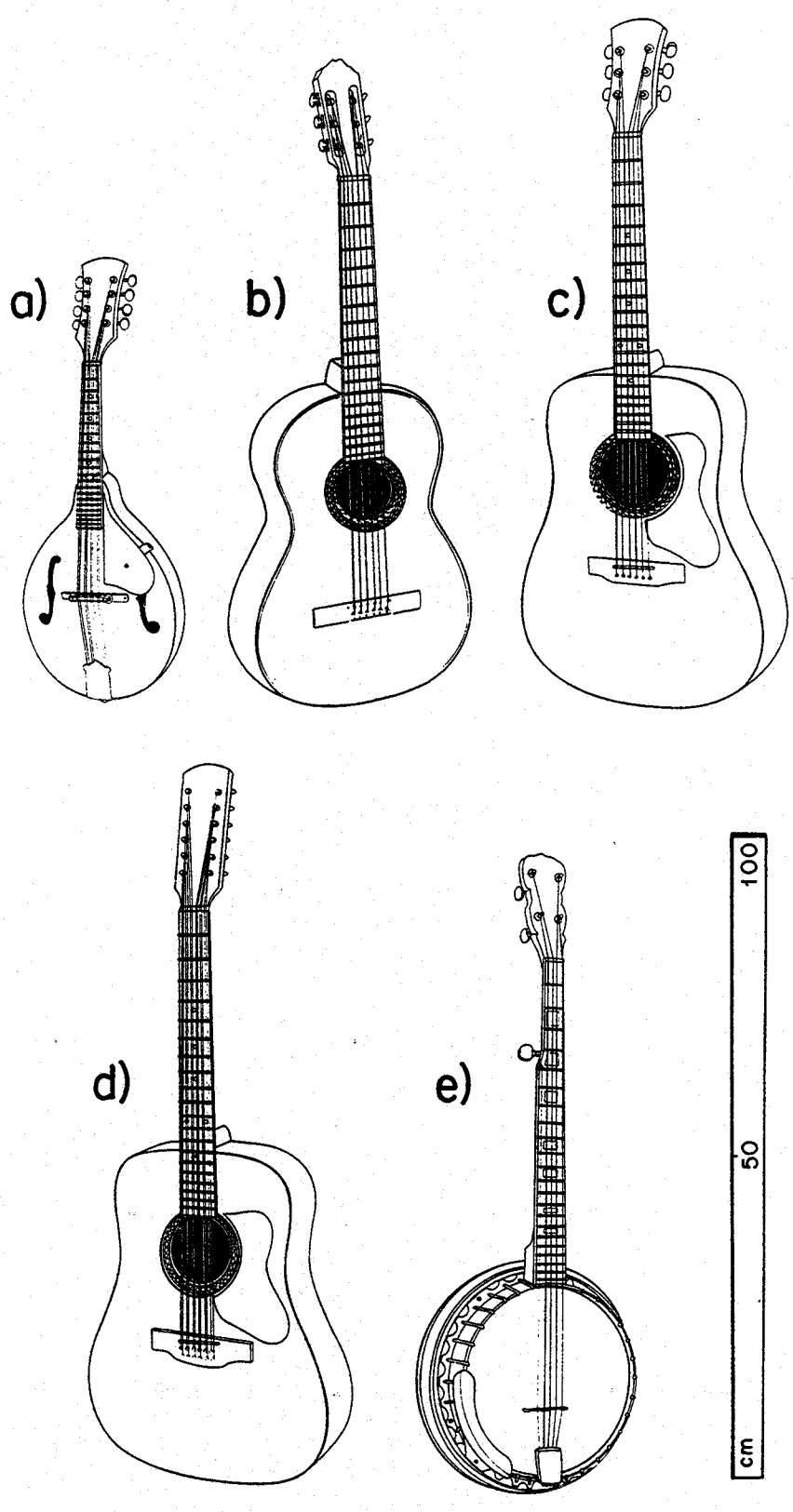


FIGURE 207. *The acoustic guitar and related instruments: (a) mandolin; (b) classical guitar; (c) folk guitar; (d) twelve-string guitar; (e) five-string banjo.*

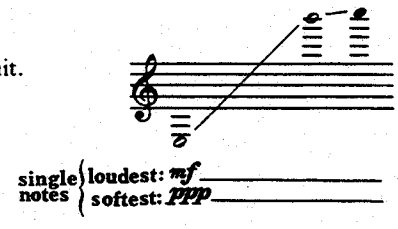
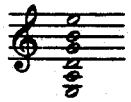
name of instrument	*abbreviations*	*written range*	*tuning*	*sounds*	*availability*
guitar	guit.			1 octave lower	classical: common folk: ubiquitous 12-string: common

FIGURE 208. *The guitar—vital statistics.*

The **folk guitar** has wire strings, with a narrower neck and shorter body than the classical guitar. The body intersects the neck at the fourteenth fret. This is the standard "acoustic guitar" of popular music, and it has a brighter and more penetrating tone than the classical guitar.*

The **twelve-string guitar**, as its name implies, has geminated strings, the lower three courses being tuned in octaves (8′ + 4′), the upper three as unisons. The two strings in each course lie very close together and are plucked simultaneously. The strings are of metal; the large body intersects the broad neck at the twelfth fret. The instrument is designed to give a particularly full, rich sound and is typically used to provide chordal accompaniments in popular music.

Guitars of all sorts are held on the player's lap (or hung from a strap around the neck) with the instrument's neck to the left. In this playing posture the lowest string is in the highest position, i.e., closest to the player's head.

RIGHT HAND TECHNIQUE

The classical guitar is plucked with the nails of the first four fingers of the right hand. Scalewise passages are usually played with alternating index and middle fingers or, in more rapid passages, index and ring fingers. For very rapid repeated notes (even tremolos) the index, middle, and ring fingers are all used in rapid alternation. In polyphonic playing the different fingers will usually pluck different strings, the thumb always being lowest whenever it is used and the ring finger highest.

Two types of stroke are used. The **rest stroke**, in which the finger after plucking the string comes to rest against the neighboring string (the next higher string for the thumb, the next lower for the other fingers), is capable of considerably more speed and power than the **free stroke**, in which it does not. The free stroke is, however, essential for polyphonic playing and all other situations where adjacent strings must sound at the same time. In poly-

*The **dobro** or **resonator guitar** is a folk guitar with a partly metallic body and a correspondingly twangy, metallic sound.

phonic playing (up to three fully independent parts or four partly independent ones) the fingers never cross each other.

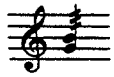
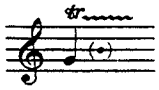
Any chord of more than four notes, as well as any other perceived by the guitarist as essentially homophonic in function, will be strummed (i.e., very rapidly arpeggiated) with the thumb. For the maximum possible force the same thing can be done by flicking across the strings with the backs of the nails of all the other fingers together; this last is a specifically flamenco technique, and must be specified. Degrees of arpeggiation are indicated on the guitar as follows:

 = non arpeggiato

 or  = rapid strum in the indicated direction

 or  = leisurely arpeggio in the indicated direction

In the slow arpeggio each note is plucked separately by a different finger. In the absence of any special indication the guitarist will play a mixture of strummed and unarpeggiated chords.

Tremolo chords can be played by strumming rapidly back and forth across the strings with all the fingers in a loose rotary motion. This too is a special flamenco technique called **rasgueado** and such tremolos should not only be notated as such, e.g.,  , but should bear the cautionary indication "rasgueado" as well, especially since guitarists tend to read such notations as wide trills (the so-called "fingered tremolo"), thus for  playing  . Composers should not perpetuate this confusion of notation and terminology, but should write a tremolo where a tremolo is desired and a trill* where a trill is desired.

A greater variety of right-hand techniques are used on the folk and twelve-string guitars than on the classical guitar. There is no reason that any of the techniques described below could not be used on classical guitar, but they are non-traditional there and must be specifically requested when desired. Folk and twelve-string guitars may be played in the standard classical manner just described; or they may be plucked with the flesh of the fingers (which gives a more blurred, indistinct attack); or with a single **flat pick** held between the thumb and index finger and giving a powerful, strong tone though capable of playing only single melodic lines and strummed chords; or with a **thumb pick** attached directly to the thumb and used in the same way, with or without the aid of the other fingers, which may or may not be supplied with **finger picks**. Thumb and finger picks are essentially large, powerful artificial fingernails and are designed to give the loudest and strongest possible tone to this soft and delicate instrument.

* Those unwilling to untraditionally use the notation  for trills more than a second in width should use the older  which, however clumsy and illogical it may be, has at least the virtues of unambiguity and traditional approval.

LEFT HAND TECHNIQUE

The basic left-hand fingering pattern for the guitar is shown in Figure 199. Average maximum stretches along one string are as follows:

From the first fret

To Finger	Stretch From Finger 1	2	3
4	perf. 4th	$m3^d$	$M2^{nd}$
3	$M3^d$	$m3^d$	
2	$m3^d$		

From the seventh fret

To Finger	Stretch From Finger 1	2	3
4	perf. 5th	perf. 4th	$m3^d$
3	aug. 4th	$m3^d$	
2	perf. 4th		

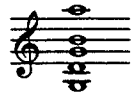
From the twelfth fret

To Finger	Stretch From Finger 1	2	3
4	m6th	perf. 4th	perf. 4th
3	perf. 5th	$M3^d$	
2	aug. 4th		

To find the maximum interval stretch on two different strings, simply add together the single-string maximum and the interval between the open strings. It must be remembered that these stretches are maximums and hence rather awkward. Normally there will be only one fret between adjacent fingers in any fingering combination—anything more is considered an **extension.**

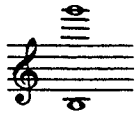
In gauging the possibility or difficulty of a given chord the following two rules should also be taken into account: (1) a higher finger (in number) will never stop a lower fret than a lower finger (e.g., the middle finger will never stop a lower fret than the index finger does); and (2) when two or more fingers stop strings at the same fret, the lowest-numbered finger will take the lowest string, and so on up in order. There are a few exceptions to this rule, but they are not important for the composer to know.

It is possible to lay the index or little finger flat across several strings at once, stopping all of them; this is called a **barre.** Any number of strings may be involved, but all must be adjacent. A **full barre** of four or more strings must include the first (e^1) string. A **partial**

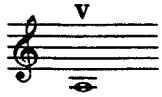
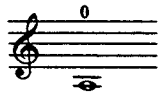
barre of two or three strings entails the complete muffling of the next higher string above the barre unless another finger stops that string at the same or a higher fret. Needless to say, any strings stopped above the barred fret will not be affected by the barre. In folk and twelve-string guitar-playing a barre-like configuration is used to prevent unwanted strings from vibrating: the tip of a finger stops a string in the normal way while damping one or two higher strings. This allows the strumming of chords such as this:  whose notes would otherwise have to be plucked separately. There is no reason this technique could not be used on classical guitar—it is just not traditional.

A full barre cannot be made above the point where the neck meets the body of the instrument. Partial barres can be made up to the highest complete fret (the last fret or two frequently serve only the e^1 string).

On folk guitar the left thumb is frequently used to stop the E_0 string, thus enabling the player to stop up to five of the instrument's six strings simultaneously with different fingers. When the thumb is used it must be no more than one fret above or below the index finger. The necks of classical and twelve-string guitars are too wide for this technique to be of any real use.

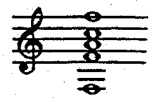
A totally unorthodox technique for use in compositional emergencies involves bringing the whole hand around the neck so that (as on the cello) the thumb can stop a string—enabling huge stretches (an augmented fourth from the first fret, a minor sixth from the seventh fret) and sonorities such as  which would otherwise be impossible to produce. If used, this technique requires about a half-second rest for the player to get the hand in position. But one should ask if the whole thing is really necessary; the example given above, for instance, could be played in the ordinary way just by transposing it down a whole step and using the open A_0 string.

NOTATION

Where necessary, guitar fingerings can be indicated as follows: the fret number is designated with a Roman numeral, fingers are numbered with Arabic numerals (0 signifies an open string), and circled Arabic numerals denote the strings (① being the highest string and ⑥ the lowest). Fingering should be indicated only to clarify a tricky or deceptive passage or where a special tonal effect is desired, e.g.:  as opposed to  . It will seldom be necessary to specify more than one of the three variables, since when one is known the other two usually follow logically.

Popular music uses a variety of special tablature notations for the guitar, of which the commonest is a stylized picture of the neck of the instrument with dots indicating the placement of the fingers:  .

The lowest string is at the left, and the heavy line across the top represents the nut. The curved line connecting two dots denotes a barre; the "x" indicates that the A_0 string is not to

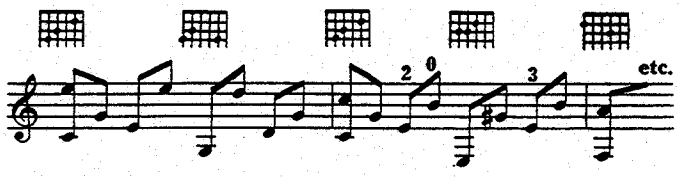
be played. This particular configuration produces an F-major chord:  . Diagrams of this type are used in popular-music **lead sheets**, in which the melody is written out in full while the (guitar) harmony is simply indicated with chord names written above the staff. Fingering diagrams are in the main only given for unusual chords or for unorthodox voicings of ordinary chords.

The fingers of the right hand are indicated by the letters *p* (or ♀), *i*, *m*, and *a*, respectively. These notations will seldom be needed by composers, save for an occasional *p* to clarify accentuation and phrasing.

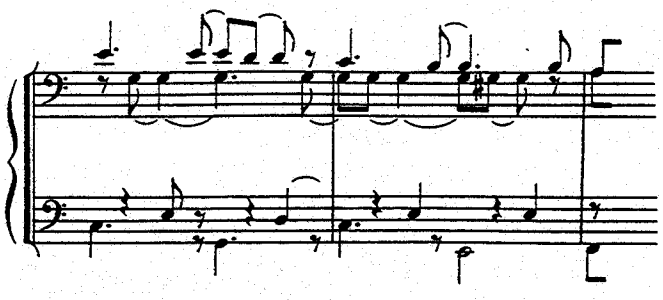
ARTICULATION

It is traditional for guitarists to leave all notes ringing indefinitely unless they are marked staccato or followed by a rest—or until either the string or finger involved is needed for another note. The decay times of the open strings of the guitar vary from four seconds for the highest string to eight seconds for the lowest. Stopped tones last from two seconds (on the e^1 string) to six seconds (on the E_0 string). Very high notes may ring for as little as one and a half seconds.

All this must be borne in mind by anyone writing for the guitar, for guitarists use the overlapping sounds of individual notes much as a pianist uses the sustain pedal, to make the sound fuller and to bring out the harmonic rhythm; but they do so automatically, *according to what the composer has required of the left hand.* If the music is written in such a way that frequent awkward or *harmonically* pointless changes in the configuration of the left hand are required, it will sound hesitant and gawky no matter what the player does. Furthermore, one of the foundations of guitar technique is the use of overlapping single notes to make counterpoint out of what is notated as a disjunct monophonic line; the slight differences in timbre of the different strings aid in this. This is even the case in flat-pick folk style, though admittedly not as much as in other idioms. As an example of this technique, here is a standard pattern used in popular music, as it might be notated (here with fingerings added):



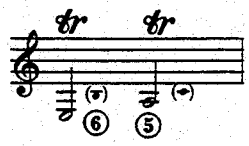
and as it would sound:



The effect is of two quite distinct outer parts plus two somewhat less well-differentiated inner voices.

Articulation on the guitar is normally detached and tenuto, with slurs frequently used simply as phrasing indications, but the instrument is capable of a true legato—within certain limitations. An upward slur is produced by fingering a note, plucking it, and then stopping the already vibrating string with another finger at a higher fret; for a downward slur the string is stopped at both pitches simultaneously (only the higher will sound), then the higher finger is lifted. If the fingers are moved in the normal way in slurring, there will be a drop of about two dynamic levels between the note plucked and the note slurred; to keep up the volume the player makes subtle use of the techniques of **hammering-on** and **pulling-off**. In the upward slur the second note is stopped with a sudden, percussive hammering motion, while in the downward slur the upper finger delicately and glancingly plucks the string as it is lifted off. By these means a legato passage can be continued indefinitely in *pp* or *ppp*—but all slurs can contain only four different pitches (five, if an open string is used) since all notes must be produced on one string and without moving the hand along the neck. The only exception to this is the *glissando* (actually a rip, and so notated) produced by sliding a single finger along the string without lifting it. Minor-second slurs produced by this means are notated as portamentos (); other slurs are notated in the normal fashion,  , and composers are urged to use this notation only where a true legato is desired.

Trills on the guitar are normally produced legato and should therefore be short except in *pp* or *ppp*. Long trills will wherever possible be played on two strings by alternate plucking, as will trills greater than a second in width. If there is any doubt, the way in which a trill is to be played can be specified by indicating the string(s) on which its notes are to be played:



Hammering-on and pulling-off can be used as special effects in their own right, and when so used are produced more forthrightly than when they are used as aids in the production of legato. Hammering-on can be done no louder than *piano* unless the string involved is already vibrating. The sound, as might be expected, is delicate and percussive. The notation  is recommended but will have to be explained. Pulling-off can be performed as loudly as *mezzo-forte* and always has a pingy, *sul ponticello* timbre (see below). The notation,  , may have to be explained.

Staccato notes can only be played slowly on the guitar since each note must be damped separately, either by hand or by slightly lifting the left-hand finger if the note is a stopped one.

Notes may be muffled () with the base of the right hand as they are plucked (this effect is rather inappropriately called "pizzicato") or damped out entirely with unused left- or right-hand fingers laid loosely on the strings.

The vertical Bartók-pizzicato of the violin family is possible on the guitar: the string, held between two fingers, is pulled vertically and allowed to snap back against the fingerboard. The standard notation for this is  , but as it is not a common technique on the guitar it may have to be explained.

The tuning of the guitar gives it a marked propensity for the key of E, in which the open strings can be used to great advantage to make the sound of the instrument particularly full and rich. While music in other keys—or in no key—can be quite effectively played on the guitar as it stands, folk and twelve-string players frequently make use of scordatura to bring this richness to other keys; a common "D-tuning," for instance, is D_0, A_0, d^0, $f\sharp^0$, a^0, d^1. These players also make frequent use of a device called a **capo** (short for "capotasto"—Italian for "master fret") which when strapped around the guitar neck (this can be done in a few seconds) acts as an artificial nut, clamping the strings down firmly at that fret and effectively transposing them all upward. Of interest to composers is the fact that these "artificial" open strings sound more thin, ringing, and brilliant—mandolin-like—than the unaltered ones, and more so the higher the fret at which the capo is attached. This can be heard clearly at the beginning of the Beatles' "Here Comes the Sun," where the acoustic guitar with capo at the fifth fret stands out prominently. There is no reason that a capo could not be used on a classical guitar to produce a similar effect—it is just not traditional. Capos are seldom used above the seventh fret.

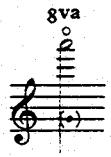
The detached, precise tone of the guitar demands transparent textures and well-spaced harmonies, particularly in the bass. A little experimentation with simple chord fingerings will show that the guitar's tuning system is engineered to provide such spacings easily and naturally.

When melodic lines move by leap, especially in broken chords, the guitarist will endeavor to find a single *chord* fingering—or as few such as possible—covering the necessary notes so that the left hand can be held steady while the right hand plucks various strings. This is especially important in polyphonic writing, which the player's left hand will treat as a simple progression of chords while the polyphony is articulated by the right hand. Composers should therefore keep to a minimum the number of times in which awkward shifts are required of the left hand. The best progressions allow the player to keep one or more fingers stationary, shifting the other fingers around them.

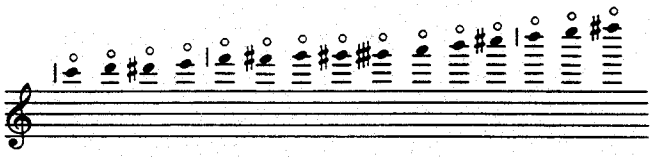
The tone of the guitar can be altered by varying the place at which the strings are plucked. Plucking near the bridge (*sul ponticello*—usually written out in full, but if necessary abbreviated "pont.") produces a pingy, snarling sound reminiscent of the harpsichord. Plucking near or over the fingerboard (**sul tasto** or **sulla tastiera**) yields a particularly thick, smooth tone. Playing exactly in the center of the string (*molto sul tasto*) makes the sound extremely sweet and pure.

Natural harmonics on the guitar are available from the second to ninth partials inclusive. Partials above the sixth are tricky; they require a second or two of preparation time and must be plucked *sul ponticello.* They are most easily produced on the e^1 string. Harmonics up to the sixth can be barred. Natural harmonics can if necessary be produced by the right hand alone on the second, third, and fourth partials, and two simultaneous harmonics can be played thus if they are made at the same node on adjacent strings.

Artificial harmonics are produced on the guitar by stopping with the left hand while plucking and touching the node with the right. They are normally produced singly and only at the second partial, but the third and fourth partials can be used, and two-note artificial-harmonic chords can be played provided the notes are on adjacent strings and their nodes are right next to each other. Artificial harmonics must be played slowly and are difficult or impossible to produce from notes stopped above the twelfth fret. Artificial and natural harmonics may be combined with each other and with regular notes in chords.

The sound of harmonics is delicate and impersonal, but the full complement of plucked attack noise gives them a somewhat sforzando character at all dynamic levels. They are also softer than regular notes. All these characteristics become more marked the higher the partial used. Natural harmonics should be notated like any other guitar notes (i.e., an octave above their actual pitch) with the usual little circle above the note to indicate that it is a harmonic. The exact choice of node and so on should be left to the player. Artificial harmonics should be notated on long stems with the stopped pitch indicated as a small note-head in parentheses, thus:  . This is also a useful notation when natural harmonics at the unusual seventh or ninth partials are to be played: 

. As this example shows, natural harmonics extend well above the highest stopped note. The following very high notes are available (actual pitches):



Artificial harmonics cannot be played this high.

Six high quarter-tones are available as seventh-partial harmonics, but microtones are available in other ways as well. The most conventional of these is the use of **bent tones** produced by pushing or pulling the string sideways with the stopping finger, raising the pitch by as much as a semitone. The next higher string will be prevented from vibrating unless it too is "warped" in this way. Bent tones are most easily produced on the folk guitar, on which the low E_0 string can be warped up as much as a whole step. The guitar's **vibrato** is produced similarly, but by a *lengthwise* shaking of the left hand. It is normally used only in slow-moving, emotional passages and should probably be specified where desired. Neither bent tones nor vibrato can be produced on an open string.

SPECIAL EFFECTS

Bent tones are normally used to inflect a pitch that starts or ends normally. Solid microtones are best obtained either by scordatura (remember, though, that each string tuned to a microtone will give microtones *from every fret*) or by **bottleneck technique**. For bottleneck play-

ing the guitarist wears a rigid metal, glass, or plastic tube around the left index finger or little finger. This tube stops the strings *without depressing them against the frets*, thus enabling easy production of true glissandos and microtones of all sorts. The tube can, of course, only be used in barres, but some flexibility is given by the other left-hand fingers, which are used normally. Bottleneck playing is a folk-guitar technique that is perfectly usable on the other types of guitar. It must be specified whenever it is desired.

A very recent innovation of much promise is the development of guitars with interchangeable fingerboards. These fingerboards have various arrangements of frets so that different scales and temperaments can be produced. Among the various fingerboards being manufactured are those with twenty-four equal-tempered notes to the octave, twelve-note just intonation, twelve-note mean-tone tuning, and Harry Partch's nineteen-note justly intoned scale.

Special effects on the guitar are largely limited to tapping the instrument with the side of the thumb, the knuckles, or the back of a fingernail (using the tip would damage the instrument's finish) of the right hand. Most traditional of these effects is the **tambour**, in which the guitarist taps either the bridge or the bottom ends of the strings with the side of the thumb. This produces a drum-like percussive sound in which the pitches of the strings will be clearly heard. Composers should indicate whether they wish the strings to be damped out by the left hand and whether it is the strings or the bridge that is to be tapped. The strings will also vibrate (though very weakly) when the body of the instrument is tapped. The *tambour* can be as loud as *forte*, other tapped sounds no more than *mezzo-forte*.

A tearing or squawking sound can be made by running the fingers or fingernails lengthwise along any of the three wound bass strings. A bit of this occurs inadvertently during hand shifts in normal play.

For the "snare-drum effect" the player twists two strings together with the left hand so that they buzz delicately against each other when plucked. The sound is more reminiscent of a clock-coil or sansa than of a snare drum, particularly in *sul ponticello*. The pitches of the strings will be about a half-step higher than one would expect them to be. Once the strings are twisted together the fingers not involved in the twisting can be used to stop higher pitches in this sound (one finger can stop both pitches simultaneously), and the twisting finger itself can be slid toward the nut as far as the third fret—below the third fret this effect cannot be produced.

Soft, bell-like sounds of indeterminate pitch can be obtained by plucking the strings behind the nut. Finally, the instrument can be **bowed** with a cello or contrabass bow. Since the bridge is flat rather than curved only the outer (e^1 and E_0) strings can be bowed separately.

Musical Examples

CLASSICAL GUITAR:

Britten, *Nocturnal*
Webern, *Drei Lieder*, Op. 18
Boulez, *Le Marteau sans maître*
Henze, *El Cimarrón*

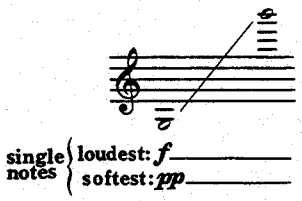
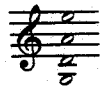
name of instrument	*abbreviations*	*written range*	*tuning*	*sounds*	*availability*
mandolin	mand.			as written	usually available

FIGURE 209. *The mandolin—vital statistics.*

FOLK GUITAR: (FROM THE POPULAR LITERATURE):

Paul Simon, "Peace like a River" (two tracks)
Joni Mitchell, "Little Green" (capo 3d fret)
The Incredible String Band, "Astral Plane Theme"

TWELVE-STRING GUITAR (FROM THE POPULAR LITERATURE):

Leo Kottke, "Easter and the Sargasso Sea"
Jefferson Airplane, "Embryonic Journey"

THE MANDOLIN

The mandolin is not, strictly speaking, a member of the guitar family, but it is used in both classical and popular music as a "soprano guitar."* It is placed *above* the guitar in scores where both appear. It has eight metal strings in four unison courses, tuned exactly like a violin; in fact, most mandolin players are also violinists. The lowest pair of strings is wound. The distance from nut to bridge on the mandolin is a couple of centimeters longer than on the violin, but the basic fingering pattern (Fig. 199) and maximum stretches (Fig. 220) are identical to those on the violin. Chord fingering and other left-hand techniques such as barre, hammering-on, and pulling-off are as for the guitar. Folk mandolinists use the left thumb to stop the g^0 strings (only in chords, not for individual notes); they also, though rarely, use a capo. Bent tones, while possible on the mandolin, are hard to do and very small in width. Bottleneck technique is possible on the mandolin, but unorthodox. The snare-drum effect is impossible.

The double metal strings of the mandolin are calculated to give the loudest, most brilliant, and longest-lasting sound possible from this small instrument, and the mandolin is accordingly slightly louder than the guitar, with a very bright, cheerful, tinkling tone. But the sustaining power of the mandolin is very weak, not exceeding three seconds even for the open strings, so the instrument is much more monophonic—or, rather, homophonic, since chords can be played—than the guitar. An appearance of polyphony can be produced by writing in the broken style described above for the guitar.

* Much more like a "soprano guitar" in actual construction is the **ukulele**, a tiny instrument with only twelve frets and four strings, tuned g^0, c^1, e^1, a^1. This instrument is now treated as little more than a toy, and indeed its small range, softness, lack of sustaining power, and unimpressive plunky timbre render it of doubtful value musically.

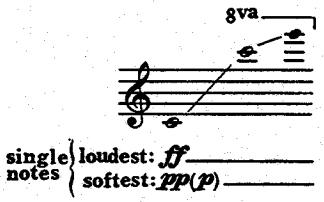
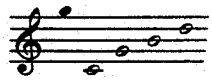
name of instrument	*abbreviation*	*written range*	*tuning*	*sounds*	*availability*
banjo	ban. bjo.			1 octave lower	usually available

FIGURE 210. *The banjo—vital statistics.*

Both folk and classical mandolinists play with flat pick only; all notes are played with the pick, and chords are rapidly strummed.

To make up for the lack of sustaining power, classical mandolinists in particular make extensive and systematic use of tremolo to produce the effect of a sustained sound for long notes and legato passages. All tremolos must be notated by the composer (the notation is  , as for other instruments).

Harmonics, both natural and artificial, are produced as on the violin; *sul tasto* and *sul ponticello* effects can be produced but have not such strikingly different tone qualities as they do on the guitar or violin.

Musical Examples

MANDOLIN:

Schoenberg, *Variations for Orchestra*, Op. 31
Stravinsky, *Agon*
Crumb, *Ancient Voices of Children*

THE BANJO

The banjo is the loudest non-electric string instrument; it is equivalent in power to the clarinet or even the saxophone. In full chords the *fortissimo* can approach *fff*; contrast this to the guitar and mandolin!

The body of a banjo is a structurally complete frame-drum (q.v.), complete with tension screws (called "brackets"). The neck sticks out sideways from the frame and the bridge is placed on the parchment or plastic **head**, which acts as a very efficient soundboard. This, combined with the instrument's thin, high-tension strings (only the lowest is wound), gives the banjo its ability to play loudly.

Banjos are made in three slightly different varieties. Of these by far the most common and versatile is the **five-string banjo**. The fifth string is a high-pitched **drone**, not intended to be stopped; nonetheless it runs along the fretboard like the other strings and can be easily stopped at any fret. It is attached, with its own nut, at the fifth fret, and its open pitch is in most tunings the same as the pitch given by the first string when stopped at that fret.

The **plectrum banjo** and **tenor banjo** have no drone string. The plectrum banjo is otherwise identical to the five-string instrument, but the tenor banjo is more distinctive in that it has a slightly shorter neck, very high string tension, and a low **action** (i.e., the strings lie very close to the fretboard). These features give it a marginally more brilliant, ringing, and wiry tone than the five-string or plectrum banjos, and make the *ppp* (easily obtained on the other instruments) virtually impossible.

The tuning given in Figure 210 is the most common of many five-string banjo tunings. Other common tunings are "open G tuning" (written g^2, d^1, g^1, b^1, d^2) and "open D tuning" (written a^2, d^1, $f\sharp^1$, a^1, d^2). A useful variant of open G tuning raises the first string to written e^2, allowing the instrument to be played with guitar fingerings. Tenor banjos are frequently tuned to written c^1, g^1, d^2, a^2, which allows easy doubling by a violist or cellist.

Banjos almost always have twenty-two frets. The upward extension tones in Figure 210 are made available by tuning the first string higher than written d^2, or the fifth string higher than written g^2. Maximum left-hand stretches are charted below.

From the first fret

To Finger \ Stretch From Finger	1	2	3
4	aug. 4th	M3d	M2nd
3	perf. 4th	m3d	
2	M3d		

From the seventh fret

To Finger \ Stretch From Finger	1	2	3
4	m6th	perf. 4th	m3d
3	aug. 4th	m3d	
2	perf. 4th		

From the twelfth fret

To Finger \ Stretch From Finger	1	2	3
4	M7th	m6th	M3d
3	perf. 5th	M3d	
2	aug. 4th		

The banjo's left-hand technique (though not the fingerings) is identical to that of the folk guitar, and most banjoists play the guitar as well. Because the tenor banjo's strings lie so close to the fingerboard, it can produce bent tones only by pushing, not pulling.

On some banjos the tuning pegs for the second and third strings are adapted for use as **Scruggs pegs**. With these, a flick of the wrist automatically raises the pitch of a string by a pre-set amount, adjustable between a half-step and a whole step. When the peg is rotated back the string returns to its original pitch. This enables nearly instantaneous retuning (compare "open G" and "open D" tunings), and the pegs can also be used to produce elegant and powerful bent tones on the open strings.

The banjo's acoustically sensitive head and shallow body make for explosive attacks and quick decays: five seconds for the open strings, two to four for stopped notes, decreasing to less than half a second at the end of the fingerboard. As a result, banjo stylings feature simple homophony or broken-style pseudo-polyphony, the latter being especially characteristic of the bluegrass music with which the five-string banjo is closely associated. The open strings are used as much as possible, which is why they are so often tuned to the notes of a major or minor triad. The banjo is picked with the first three fingers of the right hand, using either the fingertips, fingernails, or (loudest and most common) finger picks. Sometimes the remaining fingers are used to pluck a four- or five-note chord without strumming (as they often are on the guitar), but usually they are held lightly against the drum head to steady the hand. The right fifth finger can also be used to **mute** the instrument by laying it along the bridge. Chords are often strummed with a flick of the index finger or of all the fingers together (except the thumb), but this is not possible with finger picks. Tremolos are played with alternating fingers, as on the guitar.

Banjo players make frequent use of the capo. When the capo is used the fifth string may be retuned or it may be hitched around a screw the player has set into the fingerboard expressly for this purpose. There also exist special fifth-string capos which affect only that string.

Natural harmonics are available up to the fifth partial on all banjos. Five-string and plectrum banjos can reach the eighth partial, but only in the "bridge series" of harmonics (Fig. 200). Artificial harmonics are produced and notated as on the guitar.

In slow passages or on individual long notes it is possible to produce a **vibrato** by varying the pressure exerted on the drum head by the right fourth and fifth fingers, but vibrato is normally produced guitar-fashion. Resting the right wrist on the drum head will partially damp the resonances of notes played immediately before—the effect is like that produced by releasing the sustain pedal of the piano while continuing to hold down the keys. Pressing heavily on the head with the right wrist causes the pitch to bend downward about an eighth of a step. One can tap the head directly, producing a bongo-like sound.

As another special effect, very high notes of indeterminate pitch can be obtained by plucking the strings behind the bridge. Plucking behind the nut is not very effective.

Musical Examples

BANJO:

Thomson, *The Plow That Broke the Plains*
Crumb, *Night of the Four Moons*

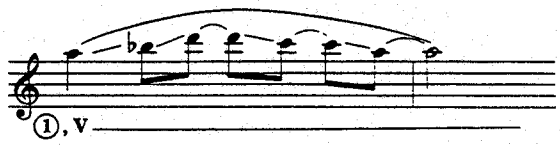
(FROM THE POPULAR LITERATURE):

Earl Scruggs, "Randy Lynn Rag"

ELECTRIC GUITARS

In an electric guitar, in place of the soundhole are one or more **magnetic pickups** that respond to the position of the instrument's metal strings, converting their motion into a changing electric voltage which is then amplified and sent to the loudspeaker, whence it emerges as sound. The body of the instrument is in most cases completely functionless acoustically, and hence may, and does, take on just about any shape, some of which are quite bizarre. The body may intersect the neck at the fourteenth fret or be cut away around the neck so that the left hand may reach even the last fret with complete freedom.

Anyone who plays electric guitar can play acoustic guitar and vice versa, for the basic technique of playing the electric instrument is identical to that of the folk guitar (described above). The only important exception is in the matter of bent tones, which can be very widely inflected on the electric guitar: up to a minor third above the "rest" pitch even at the first fret, and up to a perfect fourth from the fifth and higher frets. The player can control the pitch quite accurately and even produce bent-tone melodies by varying the pull on a single note:



In extremely bent tones the string is pulled or pushed so far that all the other strings in that direction get bunched together and are unusable as long as the bending persists.

Many electric guitars are provided with a **wiggle bar** in the form of a long handle operated by the right hand, which when pushed bends the pitch of all the strings uniformly. Some of these can bend the pitch either way, but others can only bend it downward. In any event, there is virtually no limit on the degree of downward bending—though if the pitch is bent more than about an octave down the strings become too loose to vibrate effectively, so the note decays very rapidly.

All good electric guitars have two or—less frequently—three separate pickups placed in slightly different positions. A pickup near the bridge will "hear" the strings in that position, where the upper partials are strongest, whereas one near the base of the neck will "hear" the strings where these partials are weakest; the former yields a harsh, jangling timbre, while the latter yields a smooth, almost muffled tone. The pickups are accordingly designated "treble" and "bass" (and "middle"). Mounted on the body of the guitar are separate tone controls (like the treble/bass knobs on an amplifier) for each pickup and a master volume-control knob for the whole instrument. Most two-pickup instruments have a separate volume knob for each pickup. The amplifier into which the instrument is plugged of course has its own tone and volume controls. Without recourse to the volume controls the player can differentiate only three dynamic levels on the instrument's strings.

The coarse and powerful tone of the electric guitar is utterly unlike that of the acoustic guitar—even its harmonics can cut like daggers (cf. Buffalo Springfield's "For What It's Worth"). This timbre demands the very thinnest of scoring, and the electric guitar seldom plays chords. Its genius is for melody, pure and simple; and with its great sustaining power and capacity for bent tones it is far superior to the acoustic guitar in this regard.

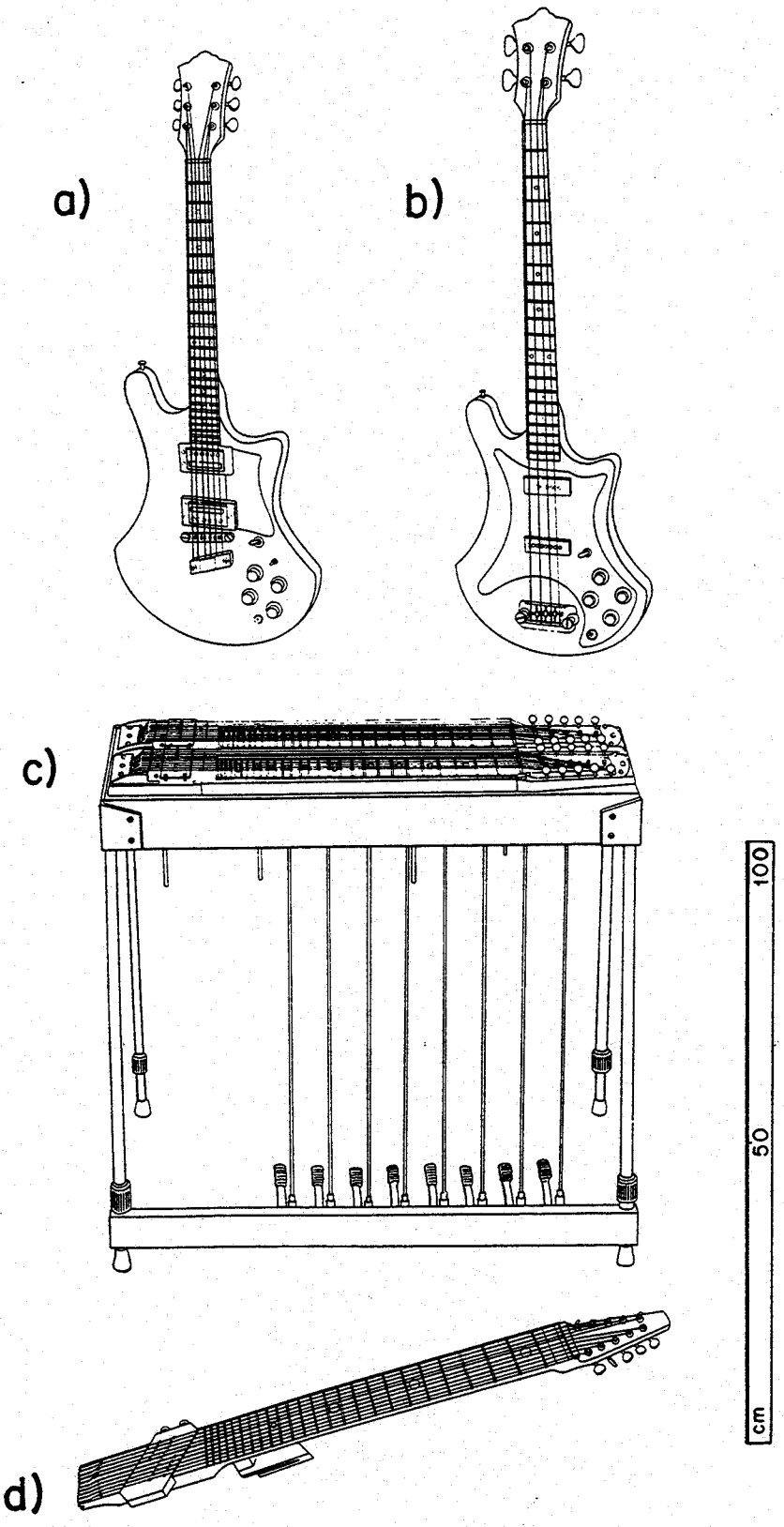


FIGURE 211. *Electric guitars: (a) electric guitar; (b) electric bass guitar; (c) pedal steel guitar; (d) Chapman stick.*

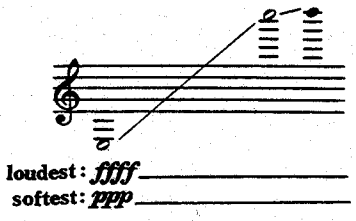
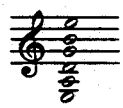
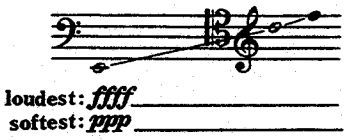
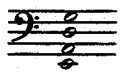
name of instrument	*abbreviations*	*written range*	*tuning*	*sounds*	*availability*
electric guitar	el. guit. elec. guit.			1 octave lower	ubiquitous
electric bass guitar	el. bs. elec. bs.			1 octave lower	common

FIGURE 212. *Electric guitars—vital statistics.*

An **amplified acoustic guitar**, whether the amplification be via air mike, contact mike, or even magnetic pickup (see Chapter X), does *not* sound like an electric guitar but retains its own nature, albeit somewhat distorted. Electric and amplified acoustic guitars are used side by side in popular music, and the distinction must be borne in mind when studying this repertoire. Also, some electric guitars (mostly those with hollow, wooden bodies) can be made to sound "merely" amplified by proper adjustment of the various tone controls, and under such conditions may well play full chords or even polyphony. **Electric twelve-string guitars** and **electric mandolins** are invariably of this type; indeed, many of these are so well designed acoustically that they may satisfactorily be played without amplification.

A number of electronic tone-modifying devices are traditionally used with the electric guitar. These include fuzz tone, reverb, vibrato, wah-wah pedal, and, recently, phaser as well. All these are discussed in detail in the next chapter. Fuzz tone in particular is so closely associated with the electric guitar that many people think of it as the instrument's normal timbre. In addition to its unique timbre, however, the fuzz box gives the player access to a variety of feedback phenomena that are otherwise available only in *ffff* with an overdriven amplifier. Most important is the ability to *sustain any note indefinitely*, merely by adjusting the controls properly and "aiming" the guitar at the loudspeaker so that its output will reinforce the vibration of the strings. **Feedback** pure and simple involves a similar reinforcement of one or more upper partials—often producing a multiphonic-like effect—of any vibrating string. If the guitar is brought close enough to the speaker these squealing or squawking sounds start even if no string has been plucked. The pitch(es) of feedback are dependent on the acoustics of the strings, speaker, and hall as well as on the electronic vagaries of the amplifier and/or fuzz box, and hence cannot be predicted or specified in detail. Once produced, however, the sound can be controlled by varying the orientation and position of the guitar relative to the speaker.

Even without the fuzz box the electric guitar's great powers of sustention allow the right hand to leave off plucking the strings and come to the aid of the left hand in legato passages. Thus, the right index finger can make a full barre *above* the left hand, acting as an "instant capo." Alternatively, the right hand can finger notes near the end of the fingerboard while the left hand stays near the nut, the two together producing a highly jagged but perfectly legato line.

As a special effect the flat pick may be scraped along any of the wound bass strings, producing a rasping glissando howl of indefinite pitch. Another special effect unique to the electric guitar is the use of the flat pick to cut off each note almost immediately after it has been plucked by one of the fingers holding the pick. This sound is not merely staccato but has a choked, chirping offset as the pick briefly articulates a high harmonic while cutting off the note.

The recently invented **E-bow** is an electronic device, held in the right hand, that sets up a magnetic potential opposite to that of the pickup. When it is held just above a string the combined effect causes the string to vibrate. The E-bow, as its name implies, is thus really an electronic bow, enabling the production of very smooth attacks and indefinitely sustained tones with full control of crescendo and diminuendo.

The **electric bass guitar** (or "electric bass") is essentially identical to the electric guitar in its performance techniques, and almost everyone who plays this instrument can also play guitar.

Electric basses have two pickups with the usual separate tone controls. The neck is slightly longer than that of the guitar and the instrument is accordingly slightly less agile. Maximum stretches are as follows:

From the first fret

To Finger \ Stretch From Finger	1	2	3
4	M3^{d}	m3^{d}	M2nd
3	M3^{d}	M2nd	
2	m3^{d}		

From the seventh fret

To Finger \ Stretch From Finger	1	2	3
4	aug. 4th	M3^{d}	M2nd
3	perf. 4th	M2nd	
2	M3^{d}		

From the twelfth fret

To Finger	Stretch From Finger: 1	2	3
4	m6th	M3d	m3d
3	aug. 4th	m3d	
2	perf. 4th		

Bent tones up to a major second in width can be produced (up to a major third on the low E_1 string). Harmonics can be produced up to the eighth partial except on the E_1 string, on which only the second, third, and fourth partials are available.

Some electric basses are fretless and can therefore produce true glissandos and microtones without bending, scordatura, or bottlenecking. Their tone resembles an amplified pizzicato contrabass.

Increasingly to be seen are **double-neck electric guitars**, instruments with two parallel necks attached to one body—usually either six-string and twelve-string, or six-string and electric bass. The two necks have completely independent pickups and knobs for tone and volume.

Finally, the rare **electric sitar** should be mentioned. This is an ordinary electric guitar—with the usual complement of six strings, twenty-one frets, and two pickups—in which the strings pass over a flat metal block that acts as a bray when they are plucked, reproducing to an uncanny degree the characteristic nasal twang of the Indian sitar. The electric sitar also has thirteen **sympathetic strings** (with their own pickup) designed to enhance the sitar effect.

Musical Examples
(from the popular literature)

ELECTRIC GUITAR AND ELECTRIC BASS GUITAR:

Neil Young, "Cowgirl in the Sand"
The Beatles, "I Want You (She's So Heavy)"
Jefferson Airplane, "The House at Pooneil Corners"

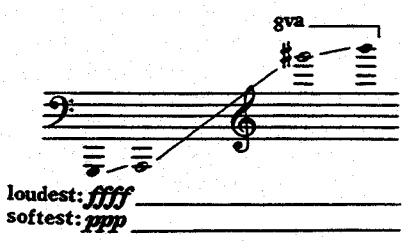
name of instrument	*abbreviations*	*written range*	*sounds*	*availability*
pedal steel guitar	ped. st. p.s.g.		as written	rare

FIGURE 213. *The pedal steel guitar—vital statistics.*

THE PEDAL STEEL GUITAR

The pedal steel guitar is a guitar in name only, for it resembles its parent instrument neither in construction nor performance. It is, nonetheless, a descendant of the acoustic guitar, and the relationship between these instruments ought to be understood.

An extreme form of bottleneck technique on the acoustic guitar involves laying the instrument flat on a table or on the player's lap, tuning it to some "open" (i.e., triadic) tuning, and sliding a heavy bar along the neck to differentiate pitches; this technique is called "Hawaiian guitar," and at one time there were guitars specially made to play in this style (cf. Weill's *Dreigroschenoper*). An electric Hawaiian guitar—often with built-in legs—is called a "steel guitar," and when this instrument was given a greatly augmented number of strings plus a set of pedals for changing their pitches (harp fashion) it became the modern pedal steel guitar, or "pedal steel" for short.

The pedal steel exists in two forms. One has two parallel necks each provided with (typically) ten strings, eight pedals for the left foot, and two levers, operated by the right knee, that also function as pedals. The other type has only one neck (usually with twelve strings), seven pedals for the left foot, two right-knee levers, and three left-knee levers.

Each string on a pedal steel guitar runs over and is attached to its own rotatable metal **bridge finger**. The bridge fingers are attached to the pedals, and when a pedal is depressed it rotates all the bridge fingers to which it is attached, lowering or raising the pitches of the strings by changing their tension. Note that this is not the same mechanism as the stopping action of harp pedals; if a pedal is depressed while a string it governs is vibrating there will be a short but clear glissando to the new pitch.

The connection of strings to pedals is almost infinitely changeable and adjustable by the player (though this is time-consuming and requires that the instrument be turned upside down). On any good pedal steel each string can be attached to *at least* three pedals simultaneously—two to raise the pitch and one to lower it. Each pedal can also be attached to several strings at once, with the same or different effect on the pitch of each. The extent to which depressing the pedal changes the pitch is freely variable from nearly nothing up to a minor

	L. Knee			L. Foot							R. Knee	
	←	↑	→	1	2	3	4	5	6	7	←	→
e^1											$-d^1$	
g^1					$+g\#^1$							
f^1												
d^1								$-c\#^1$			$+e\flat^1$	$-c^1$
$b\flat^0$	$-a^0$			$+c^1$		$-a^0$			$+c^1$			
g^0		$-f\#^0$			$+g\#^0$				$+a^0$			
f^0			$-e\flat^0$				$-e^0$					
d^0						$-c^0$		$-c\#^0$			$+e\flat^0$	
$B\flat_0$				$+c^0$								
G_0		$-F\#_0$								$+B_0$		
$E\flat_0$							$+E_0$			$-D_0$		
$B\flat_1$							$+C_0$			$-G_1$		

FIGURE 214. *Single-neck pedal steel guitar—standard copedant (B♭6 universal tuning).*

third in either or both directions. On double-neck instruments the first three (leftmost) pedals affect the rear neck and the other five affect the front one; the knee levers can be attached to either neck.

Diagrams showing the effect of each pedal are called **copedants.** These are laid out like the ones in Figures 214 and 215. The pedals are simply numbered across the top from left to right and the knee levers are designated by arrows showing the direction in which the knee must move to activate the lever. The far left column of a copedant gives the tunings of all the strings, listed from back to front. The tuning of the pedal steel guitar is as variable as that of other popular string instruments, but there are standard tunings—and, for that matter, standard copedants—for pedal steels of both the double- and single-necked varieties. These standard tunings and copedants are given in Figures 214 and 215.

In addition to the wide variety of pitches available from the open strings and from the pedals in whatever configuration, flexibility and inflection are available from the player's left hand, which stops the strings with the heavy, bullet-shaped metal bar or "steel" that gives the instrument its name and is used much like a bottleneck on a guitar. The bar is held, rounded end forward, between the thumb and middle finger, with the index finger lying on top of it to steady it. It is long enough to cover nine strings but can cover fewer by being placed so that it only partially overlaps the set of strings, sticking out beyond them on one side or the other. The bar is normally removed from the strings only when the open strings are used; otherwise it is slid from one position to the next. The bar is really a movable nut; its weight and hardness allow it to stop the string much more cleanly than the player's fingers could, and the result is that stopped notes sound just like open notes. The instrument has the bright, full, "open-string" sound throughout its range, which—again, because of the precision of the bar's action—is huge: a full three octaves above the pitches of the open strings.

Note that the bar is essentially a transposing device: the pattern of available pitches is established by the tuning of the strings, modifiable by the use of the pedals, and that pattern—including any pedal modifications—is transposed upward by the use of the bar.

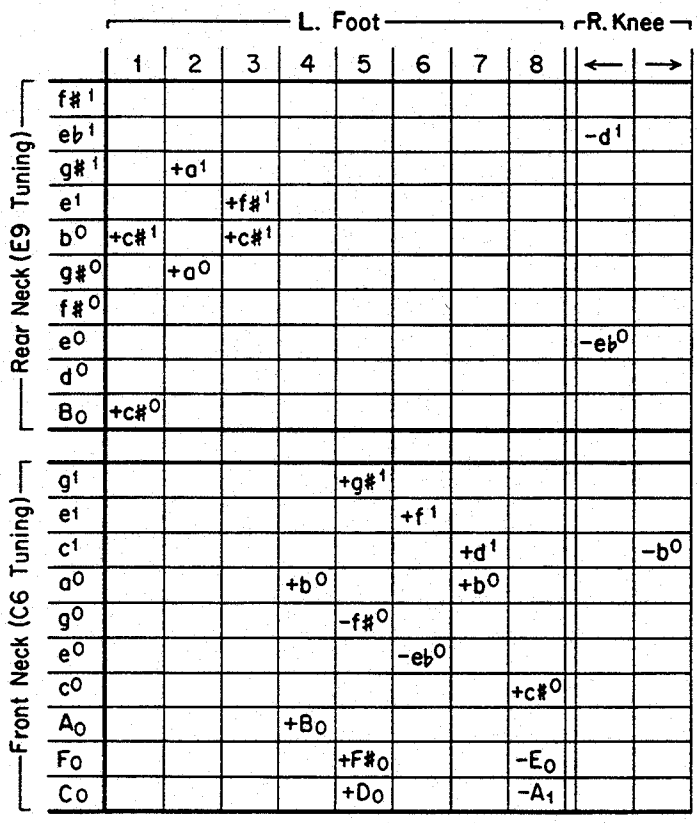


FIGURE 215. *Double-neck pedal steel guitar—standard copedants.*

The pedal steel guitar is provided with a fretboard, but the strings lie well above it and do not come in contact with it even under the weight of the bar: it serves only as a visual aid to the correct placement of the bar. Microtones, glissandos, bent tones, and other pitch inflections are all child's play with the bar; indeed, systematic use of glissando and portamento from both bar and pedals is a major feature of pedal-steel style. The bar is also used to produce a vibrato that is typically applied on a note-by-note basis, blooming separately on each pitch after it has been struck.

Special bars are used to modify the timbre. A bar with one flat side is used to get an electric sitar sound (use of the flat side produces this effect; when the bar is turned over it produces a normal sound), and a wooden bar is used to produce a very realistic imitation of a banjo.

The player's right hand is held parallel to the strings, which are plucked by thumb and finger picks. Usually only the first three fingers of the right hand are used, but all five may be.

The decay time of the open strings is about seven seconds, decreasing to five seconds at two octaves above open pitch, and to three seconds at the top of the range. Notes are normally allowed to ring for their full duration, but unwanted resonances are damped from time to time (generally corresponding to changes in the harmony) by the side of the right hand and little finger. Muting or total muffling can also be produced by this means. Placing the bar on

the strings always produces some sound; sliding it along otherwise silent strings produces a *pp* glissando. When other notes are ringing this sound is masked, but occasionally the player will want to damp the strings while moving the bar.

Sul tasto and *sul ponticello* can be differentiated on the pedal steel guitar, but there is only one magnetic pickup.

As mentioned above, the pedals are all operated by the left foot. The first three pedals are the most important, and these (or any other group of three) can be manipulated by rocking or rotating the foot without moving the heel. Two adjacent pedals can be depressed simultaneously with the toe, and up to four at once can be depressed by turning the foot sideways. The pedals and knee levers are all spring-loaded, that is, they automatically return to their normal position as soon as they are released by the foot or knee. Half-pedaling—to get a pitch change less than that for which the pedal is set up—is tricky but is in fact used from time to time. The pedal action is unfortunately rather noisy, so frequent rapid pedaling should be avoided.

In actual play it is frequently desired to change all the strings *except* the one(s) affected by a given pedal, and this is accomplished by moving the bar so that it contradicts the change imposed by the pedal. Players are actually able to hold the pitch of a string smoothly constant while it is being "fought over" by bar and pedal this way.

The right foot controls a **volume pedal**, as well as on/off buttons and control pedals for any electronic tone modifiers (vibrato, fuzz tone, etc.) that are being used in conjunction with the pedal steel. In traditional pedal steel style the volume pedal is used with great subtlety not only to control the overall dynamic level but to produce crescendos and swells on individual notes and even to inflect the attack. The volume pedal also allows notes to be sustained at a steady loudness for most of their decay time. Sometimes the player will drop the volume pedal to zero to eliminate the weak glissando produced by sliding the bar along silent strings. The fingers can produce a range of three dynamic levels without moving the volume pedal.

Natural harmonics on the pedal steel guitar are articulated with the side of the left little finger (i.e., with the bar raised off the strings). Artificial harmonics are articulated with the right ring fingertip or knuckle or with the side of the hand and are plucked with one of the other right-hand fingers. The seventh partial is the highest obtainable. Harmonics cannot be produced higher than the instrument can otherwise go (b^4).

The pedal steel guitar is fertile ground for special tonal effects, so far largely unexploited.

1. The wound bass strings (usually the lowest four on each neck) may be scraped lengthwise.
2. The instrument may be "prepared," piano fashion. Remember: the bar cannot slide past an obstruction; if the preparation is left of the bar it will probably have no effect on the sound; and the portion of the string immediately above the pickup must vibrate if anything at all is to be heard.
3. Various amplified tapping and scratching sounds can be made with the fingers on the pickup itself.
4. Unamplified (*ppp*) sounds can be obtained by plucking to the left of the bar.

5. The bar may be placed diagonally across the strings. This reduces the number of strings it can cover, as follows:

Position of Rear of Bar	Number of Frets Between Front and Back of Tilted Bar: 9	8	7	6	5	4	3	2	1
3d fret								7	9
6th fret							3	8	9
9th fret						3	6	9	9
12th fret						5	7	9	9
15th fret					4	7	8	9	9
18th fret				5	6	7	9	9	9
21st fret	5	5	6	7	7	8	9	9	9

Maximum Number of Strings Covered

6. The strings may all be bowed together.
7. Finally, the strings may be struck with a snare stick, triangle beater, or other light, thin stick. When the strings are struck right above the pickup this effect is straightforward, but when struck elsewhere one must take into account the fact that the stick stops the string, bar-fashion, for the moment that the two are in contact, and that there will therefore be a squeaky little "grace note" before each note so struck, its pitch varying inversely with the distance of the striking point from the pickup. The duration of the "grace note" can be varied by varying the mode of attack and will even be the only note produced if the stick is kept in contact with the string after each note struck.

Musical Examples
(from the popular literature)

PEDAL STEEL GUITAR:

The Grateful Dead, "The Dire Wolf"
Crosby, Stills, Nash, and Young, "Teach Your Children"

THE CHAPMAN STICK

The Chapman stick ("stick," for short) is a very recent outgrowth of the electric guitar. Available only since 1974, it has been steadily gaining in popularity and is likely to be a permanent addition to our instrumental resources. The designation "very rare" for this instrument must be considered only temporary.

All notes on the stick are produced by hammering-on. Since the instrument is not plucked, the right hand is free to articulate pitches just as the left hand does. The two hands approach the fingerboard ("touchboard," in Chapman's terminology) from opposite sides—as on a woodwind—so the fingering pattern for the two is identical, rather than opposite as on a keyboard. The maximum stretches are the same as those of the electric bass.

As Figure 216 shows, the stick has ten strings divided into treble ("melody") and bass divisions of five strings each. The lowest string in each division is in the middle of the finger-

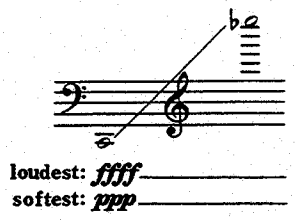
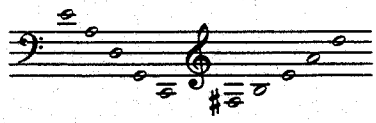
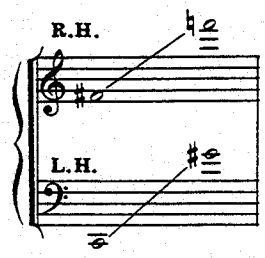
name of instrument	*abbreviations*	*written range*	*tuning*	*sounds*	*availability*
Chapman stick	stick			1 octave lower	very rare

FIGURE 216. *The Chapman stick—vital statistics.*

board; this enables both hands to play together in mid-range without getting in each other's way. Note that the third and tenth strings are unisons, the second and ninth an octave apart, and the first and eighth two octaves apart.

Either hand can play any string, but as a rule the left hand plays the bass strings and the right hand the treble. Since the right hand spends most of its time around the twelfth fret and the left up near the nut, a well-separated treble/bass texture results:



It should be emphasized, however, that either hand can play with ease at any fret. Note that in normal play both hands reach across most of the fingerboard; when they are to play in the same region of the neck or to pass each other, they must be kept out of each other's way. This is best done by having them reverse roles, i.e., temporarily assigning treble to the left hand and bass to the right.

Because of the great width of the fingerboard the thumbs are not used. The barre is possible but clumsy and seldom desirable.

The strings of the stick run very close to the fingerboard so that articulation can be as light and easy as possible. The attack can be varied from sforzando to legato, and five dynamic levels can be differentiated by the fingers alone. Despite the unique playing technique the onset of individual tones in detached playing much resembles the plucked sounds of the ordinary electric guitar. Production of the legato requires alternating fingers or, at low volumes, a slide. Chords, since they are not strummed, tend to be keyboard-like in effect.

A velvet damper runs beneath the strings between the nut and the first fret and acts like the damper felt of a clavichord or clavinet, stopping the tone instantly when the finger is removed from the string; and like the clavichord and clavinet the stick is capable of an incredibly crisp and brittle staccato, even in trills and rapid runs.

The open strings are played by ordinary plucking. Because of the damper these notes reverse the usual pattern, being *less* brilliant and resonant than the stopped notes. The open strings are seldom used except for the lowest, whose pitch is available no other way.

The tone of the stick is considerably more delicate than that of most electric guitars; it approaches the quality of an amplified folk guitar. The bass and treble divisions have separate pickups with independent volume controls and *separate output*, so that if desired the output of the two divisions may be routed to separate speakers. Since this involves separate amplifiers as well, the two divisions can be assigned contrasting tone qualities.

Fuzz-tone, wah-wah, and other effects can be used with the stick just as with other electric instruments; they all, however, tend to coarsen the tone and reduce the expressivity of the instrument, undermining the unique and impressive polyphonic potential that is the stick's raison d'être.

The behavior of the strings, in terms of vibrating duration, capacity for bent tones, and so on, is the same as that of the electric guitar and electric bass. *Sul tasto* and *sul ponticello* effects are obviously out of the question, as are natural harmonics; but artificial harmonics (attacked with one hand, the node touched with the other hand) are produced very easily.

Stick parts are best notated, piano-fashion, on two staves, one for each hand.

Musical Examples (from the popular literature)

Chapman stick:
King Crimson, "Sartori in Tangier"
"Elephant Talk"

THE VIOLIN FAMILY

The violin and its relatives are the only modern Western bowed string instruments. The bow, held in the right hand, is drawn across the strings, creating a continuous, sustained sound by friction between the hair of the bow (from the tails of specially bred horses) and the string. This friction is aided by the presence of sticky **rosin** rubbed onto the bow hairs by the player as part of the warm-up process each time the instrument is played.

The members of the violin family are as alike as the members of any woodwind family, but they are normally thought of as completely separate instruments. This is largely because their fingerboards have no frets, and in order to play in tune the player must learn through practice the exact stretches for all intervals in all parts of the fingerboard; in switching from one member of the family to another one must completely reinterpret the proprioceptive cues from the left hand in order to play in tune. The doubling violin/viola is not uncommon, however, and occasionally a cellist picks up a violin and as a joke starts playing the Dvořák cello concerto—roughly in tune.

All members of the violin family have curved bridges and fingerboards so that the bow can be used on the middle strings individually. All have four strings and all except the contrabass are tuned in fifths. All have a full, rich, singing tone. The violin and cello are particularly strong and bright in timbre, while the viola and contrabass (whose bodies are not quite big enough to resonate their lowest pitches properly) sound smoother and more velvety. All sound brighter, more focused, and more intense in their higher reaches. As usual, the open strings produce a stronger, richer sound than stopped notes.

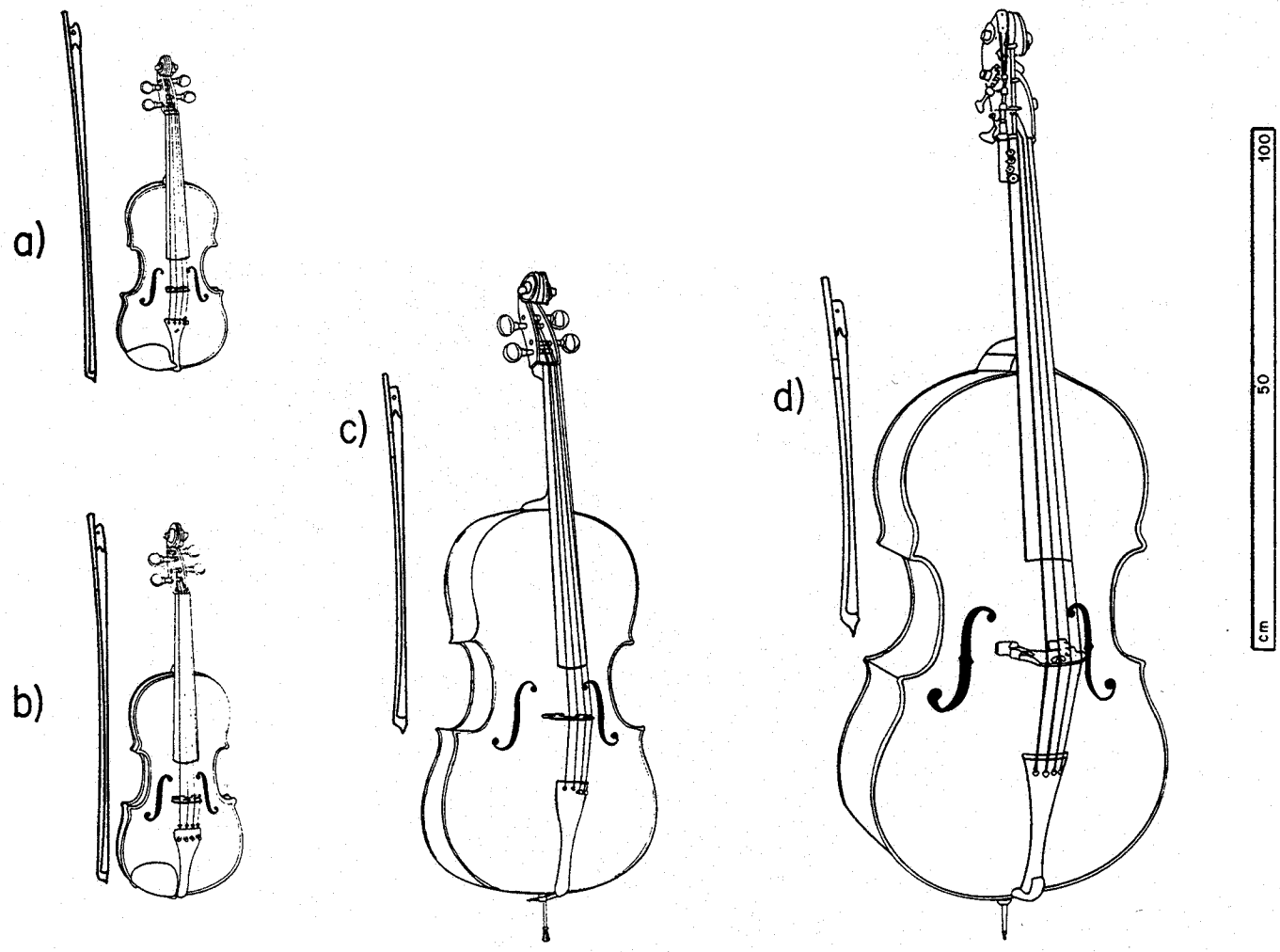


FIGURE 217. *The violin family: (a) violin; (b) viola; (c) violoncello; (d) contrabass.*

In writing for these instruments it must be borne in mind that they are soft. Their most comfortable dynamic level is *mezzo-piano*, and their *fortissimo* is barely worthy of the name—it certainly cannot compete with the *fortissimo* of the clarinet or saxophone.

It is also worth remembering that playing standards differ considerably among the different members of the family. Standards of violin playing are currently higher than for any other instrument except the piano; those for viola and cello are also high but not as spectacularly so, while contrabass playing standards—though they are rising—are the lowest of any major instrument: many *professional* players cannot even consistently play in tune.

A word about terminology: "violoncello," like "pianoforte," is now used only in contexts of extreme formality. The spelling " 'cello" (with an apostrophe) has become somewhat archaic and is fast losing ground to plain "cello." The contrabass is known under a great many names in English; in order of decreasing respectability these are "contrabass," "bass viol," "bass violin," "string bass," "bass fiddle," and "bull fiddle." All are commonly abbreviated to "bass" in ordinary conversation. The term "contrabass" is actually the least commonly em-

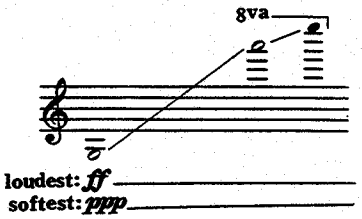
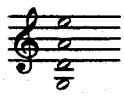
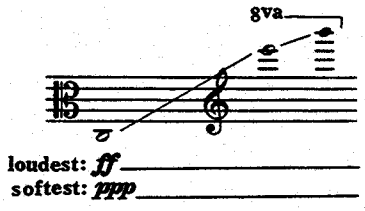
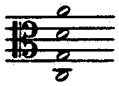
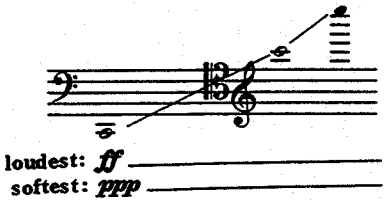
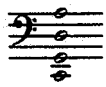
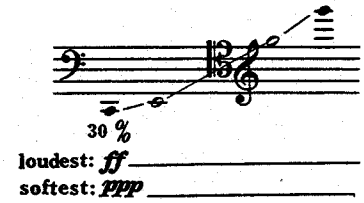
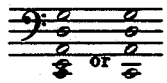
name of instrument	*abbreviations*	*written range*	*tuning*	*sounds*	*availability*
violin	vln. vn.			as written	ubiquitous
viola	vla. va.			as written	common
violoncello	vcl. vc.			as written	ubiquitous
contrabass	cbs. cb.			1 octave lower	common

FIGURE 218. *The violin family—vital statistics.*

ployed of these expressions, but it is increasingly preferred both by contrabassists and composers, because this is the name of the instrument in all European languages other than English.

Unlike the other members of the family, the contrabass varies a great deal in size, in construction, and even in technique. Most have four strings tuned in fourths from low E_1 (written an octave higher), but fully one-third of the literature for the instrument descends to C_1 and many contrabasses are built or modified to reach this note. Some of these are **five-string contrabasses** with a C_1 string added to the usual four; other players simply retune their E_1 down to C_1 when the need arises. Most common, however, is the **low C_1 extension**, which can be built in or added to an ordinary bass. The extension is just that: extension of the fingerboard past the nut to a point just beyond the top of the scroll. The lowest string passes over this extension and then back down to its tuning peg. The player does not directly stop the extended portion of the string, but rather makes use of four keys, just like woodwind keys, that stop the string mechanically for the notes E_1, $E\flat_1$, D_1, and $D\flat_1$, the levers for which

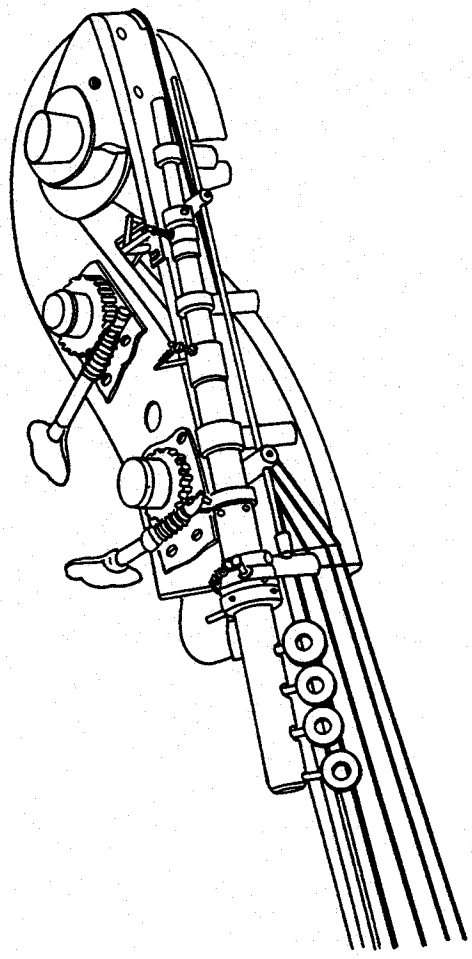
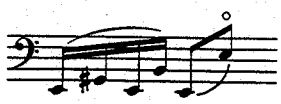
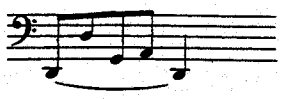


FIGURE 219. *Detail of low C_1 extension mechanism for the contrabass.*

are placed in a row at the level of the nut. By means of a lever behind the neck the player's left thumb can lock down the E_1 key, turning the C_1 string back into an E_1 string. Reversing this lever unlocks the E_1 key again, and most "machine basses" also unlock automatically whenever the $E\flat_1$ key is depressed. The "machine" can be frightfully noisy, but it is nonetheless the preferred method of reaching C_1 because a machine bass can still play passages such as



that require an open E_1 string and those such as



that would be very clumsy on a five-string instrument because of the E_1 string intervening between the C_1 and A_1 strings. Composers are advised, should they descend below E_1 in their contrabass writing, not to make parts so idiomatic for one type of bass that they cannot be

played on another. It should also be borne in mind that soloists (as opposed to orchestral players) usually prefer to use a small contrabass without the extra low notes; some even use a very small instrument tuned a whole step higher than usual, though such a cello/bass hybrid seems rather pointless.

The violin and viola are held perpendicular to the player's body with the bottom of the instrument tucked between chin and left shoulder. With the help of an attached chin rest the instrument is held firmly in position by chin and shoulder alone (players frequently develop a "violin hickey" and take to wearing scarves), so that the left hand is freed from the need to support the instrument. The cello and contrabass are held vertically and supported off the floor by an adjustable **endpin** emerging from the bottom of the instrument. The difference in playing posture means that to a violinist or violist the lowest string is at the player's left, while on the cello or contrabass the lowest string is on the right. This affects only the practice of bowing, for violinists and violists twist the left hand around the back of the neck so that the fingerboard is approached from the left side of the instrument (i.e., the player's *right*) just as it is on the cello, contrabass, or any other necked string instrument. The violin and viola are held such that the sound tends to be directed toward the player's right; therefore, in pieces where the spatial arrangement of the performers is important composers should avoid positioning these players in any way that places the audience to their left.

LEFT HAND TECHNIQUE

The basic fingering pattern for the violin was given in Figure 199; that for the viola is the same, though of course a fifth lower in pitch. The patterns for cello and contrabass are as follows:

CELLO

Finger	Pitch of Open String: C_0	G_0	d^0	a^0
0	C_0	G_0	d^0	a^0
1	$C\#_0, D_0$	$G\#_0, A_0$	$e\flat^0, e^0$	$b\flat^0, b^0$
2	$E\flat_0$	$B\flat_0$	f^0	c^1
3	E_0	B_0	$f\#^0$	$c\#^1$
4	$F_0, F\#_0$	$c^0, c\#^0$	$g^0, g\#^0$	$d^1, d\#^1$

CONTRABASS

Finger	Pitch of Open String: E_1		A_1		D_0		G_0	
0	E_1		A_1		D_0		G_0	
1	F_1	$F\#_1$	$B\flat_1$	B_1	$E\flat_0$	E_0	$G\#_0$	A_0
2	$F\#_1$	G_1	B_1	C_0	E_0	F_0	A_0	$B\flat_0$
4	G_1	$G\#_1$	C_0	$C\#_0$	F_0	$F\#_0$	$B\flat_0$	B_0

The contrabass pattern requires some explanation. There are two separate columns of notes for each string because the half-step difference between the columns requires an actual shift of the hand—not a simple extension of one finger as it would on the other bowed strings—and repeated shifts are required in order to play any scale. Note also that the large stretch between adjacent half-steps on the contrabass leaves room for only three notes within the compass of the hand, so that the third finger is normally not used—though certain patterns of notes do require its use.

For both cello and contrabass the fingering pattern changes in higher positions. In these **thumb positions** the left thumb is brought around to the front of the neck (not around the back, since the body of the instrument intervenes) and used, along with the other fingers, to stop notes. In thumb positions the fourth (i.e., little) finger is not used because bringing it into position to stop a note below the thumb would force the intervening fingers far over to the side where they could not reach the strings. In thumb positions (which begin in about fifth position on the cello and seventh position on the contrabass) the fingering pattern becomes fully diatonic, as on the violin.

The thumb may if desired be used in lower positions if an unusually large stretch is required (see chart of maximum stretches). Its use in such cases should be designated by the conventional "thumb" symbol, ♀ .

The chart below gives the average maximum left-hand inter-finger stretches for all members of the violin family. These maximums should be consulted whenever there is any doubt as to the feasibility of any chord (called **multiple stop** on these instruments) or artificial harmonic.

It is worth noting here that it is possible to stop notes beyond the end of the fingerboard, simply by pressing hard on the string. In Figure 218 the note produced on the highest string at the end of the fingerboard is given as the uppermost note of the "normal" range, while the highest note beyond the fingerboard is shown as the top of the upward extension range. Intonation is very tricky in these high notes, particularly on the violin and viola.

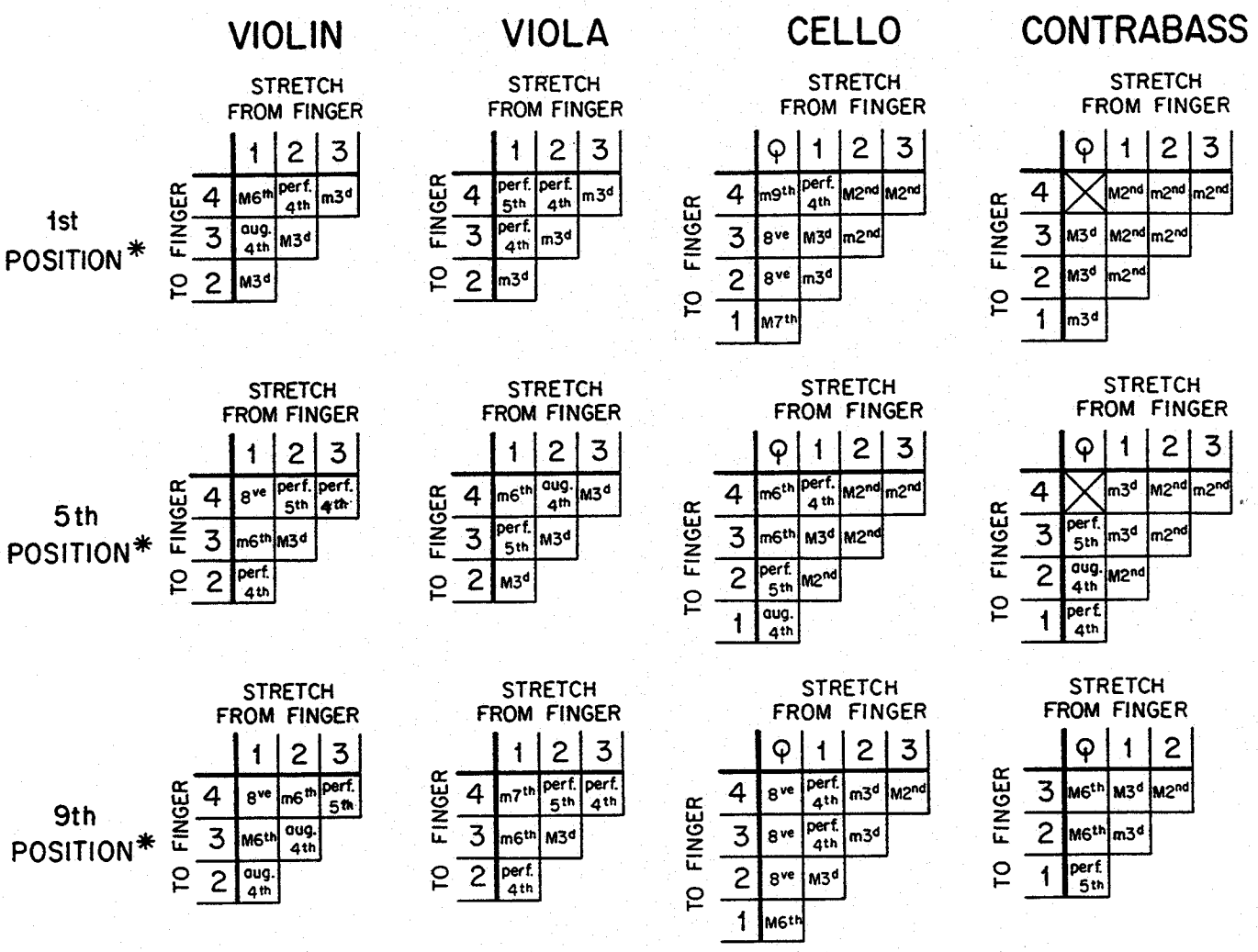
BOWING

The **bow** is held at its right end, the hand grasping it from above with the thumb on one side and the other fingers opposite it. True to form, the contrabass is a partial exception to this, for those players who use the so-called **German bow** (as opposed to the regular **French bow**) hold it underhand, gamba fashion (see Chapter XIII).*

The player's bowing arm is held well out from the body and the bow is moved mostly from the elbow. In ordinary detached playing the direction of motion of the bow is alternated with each note. Strokes in which the hand moves away from the instrument (**downbow**) are marginally more powerful than those in which the hand moves toward the instrument (**upbow**), and players automatically start each passage with an upbow or downbow depending on whether its first note falls on a weak or strong beat or division of a beat.

In some cases the bowing pattern will have to be reversed halfway through a passage, or

* Unlike a gamba bow, however, the German bow's power stroke is the downbow, just as with the French bow.

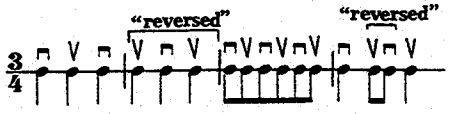


*Positions are diatonic and represent the position of the first finger or thumb. Thus, in first position the first finger is placed a major second above the pitch of the open string; for fifth position it is placed a major sixth up, and in ninth position a major tenth up.

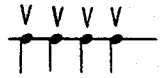
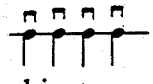
FIGURE 220. *Maximum single-string interval stretches between all pairs of fingers in different positions on members of the violin family. Violin figures are also valid for mandolin (q.v.).*

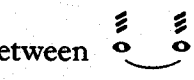
the whole passage may require unorthodox bowing, in which case the composer may wish to indicate the proper bowing with signs for upbow (V) or downbow (⊓), thus:

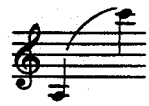
It must be emphasized that it is not essential for the bowing pattern to correspond with the metrical accentuation in every detail. In three-quarter time, for instance, the normal alternation of upbows and downbows frequently produces "reversed" bars:

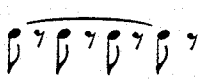
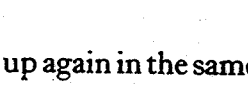
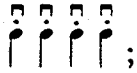


but the difference in weight of upbow and downbow is so subtle that no need would be felt to break the alternation.

Players can normally be trusted to work out the best bowing pattern for themselves. In deciding whether to introduce a break in the bowing pattern the composer should be aware that the production of two downbows or two upbows in a row requires the lifting and repositioning of the bow so that the first note in any such pair will always be at least somewhat staccato. Such repeated upbows and downbows can be used to give a breathless  or stomping  quality to the music.

For bowed instruments the slur indicates specifically that all the notes included thereunder are to be taken in one stroke of the bow. The maximum time that can be allotted to a slur (or to a long single note) before the player runs out of bow varies from about three seconds in *fortissimo* to *at least* thirty-five seconds in *ppp*. The figures are somewhat shorter for the contrabass than for the other members of the family. Players are adept at changing the direction of the bow almost imperceptibly if need be, and composers frequently write extremely long notes and slurs with the caution "change bow imperceptibly." In orchestral writing, slurs and long notes can be held indefinitely by the simple expedient of having the different players in the massed section change bow at different times; this they will do automatically whenever circumstances demand it. The **tremolo**, performed by rapidly alternating the direction of the bow and notated with three lines through the stem of each note affected, can be used to continue a tone or slur indefinitely but is more usually employed as a timbral effect. One should distinguish carefully between  (a continuous tremolo) and  (two separately attacked tremolos).

All slurs must be between notes on the same or adjacent strings, and if the left hand is required to shift more than one position between two slurred notes there will be an audible portamento between the notes. Thus on the violin, for instance, a slur such as  can only be performed with an audible glide. Note that on the cello, where a^0 is an open string, this same slur could be made without a shift and hence without a glide.

The notations  , , and  indicate that the notes are to be played, respectively, staccato, tenuto, and separated by rests, but without alternating or repositioning the bow between notes. The notes are separated by merely stopping the bow and starting it up again in the same direction. Note that  is not the same as  ; the latter implies that the bow is to be picked up and "started over" for each separate note, whereas the former indicates that the bow is simply to stop between notes without being repositioned.

The effect of this **portato** bowing is a genuine connectedness among the notes despite their clear and complete detachment. The intent of these notations when applied to other instruments of other sorts is precisely the imitation of this portato sound.

The whole question of bow articulation has been the subject of unforgivable mystification by violin pedagogues, who have applied a battery of conflicting and imperfectly defined French and Italian terms to every conceivable motion of the bow. The limited usefulness of this terminological apparatus is reflected in the fact that no two string players, string teachers, orchestration texts, or organologists will agree as to the exact meaning of all these terms or even how many discrete phenomena are being labeled. However, it is necessary to know something of bow articulation in order to write intelligently for these instruments, and, unfortunately, the existing confused proliferation of terms is all we have to work with.

The most important distinction is that between bowing "**on-the-string**" and "**off-the-string.**" In playing on-the-string (**alla corda**) the bow is not lifted between notes, and when it stops it forcibly stops the vibration of the string before starting the next note. This is the normal articulation of detached notes at slow and moderate speeds and of the tenuto at all speeds. Ordinary detached, on-the-string playing is pretentiously and unnecessarily referred to as *détaché*, and the tenuto portato is equally unnecessarily called *louré*. The sharp staccato

() is performed on-the-string, acquiring its pointedness from the fact that the notes are individually cut short by stopping the bow—a technique called **martellato**, which is usually also used to differentiate  from  . The notation is usually taken to imply an unaccented staccato alla corda.

Ordinary staccato is almost always played off-the-string, that is, the bow is lifted from the string following each note. At slow and moderate speeds this is done note by note, the bow being physically lifted by the player's arm after each stroke (**spiccato**); at higher speeds (or in isolated short notes) the bow is literally bounced off the string (**saltando**). For a particularly connected effect or at very high speeds, the bow is allowed to bounce repeatedly of its own volition (**jeté**—French for "thrown"; the Italian equivalent *gettando* is almost never seen), the speed of the bouncing (which can be increased or decreased at will) being controlled by the pressure with which the player holds the bouncing bow against the string. Most authorities maintain that the *jeté* is to be used only for rapid staccato portato. Some do not distinguish *saltando* from *jeté* at all, and the distinction is admittedly fairly academic. At any rate, the *jeté* can be used to make a **spiccato tremolo**, notated  .

The vexed question for bow articulation is what to do with rapid passages marked neither staccato nor tenuto. All other things being equal, a player will perform a loud, vigorous, or muscular passage on-the-string, and a soft, delicate, or precise one off-the-string. If the composer has a preference and the solution isn't obvious from context, the passage should be marked *alla corda* or (for want of a general term for off-the-string playing) *spiccato* or *saltando.*

Whether a passage is played on- or off-the-string, the bow will always be lifted from the string following the last note before a rest. If the note in question is an open string it will continue to vibrate softly for a second or two after the bow has been lifted. If this effect is

desired it should be indicated with the usual "l.v." and/or slur-to nowhere () notations, but usually it is *not* desired, and one cannot depend on the players to damp the open string automatically, despite the obtrusiveness of this sound, e.g., at the end of a piece. To make sure an open note is damped after the bow is lifted a good stiff "non l.v!"—exclamation point and all—will be needed.

Except for the *martellato*, stopping a note dead in its tracks by choking it off with the bow must be counted a special effect. Since notations such as  or  will not be understood, it is best to indicate this effect with "railroad tracks" (//) and the instruction "choked release."

martellato

Aside from the vagaries of articulation, the timbre of the instrument can be altered in several ways by changing the manner of bowing:

1. Bowing near the bridge, **sul ponticello** (abbreviated *pont.*)—a snarling, glassy sound. Many players (particularly cellists) overdo this and end up with some high partial instead of the fundamental.
2. Playing near the fingerboard, **sul tasto** or **sulla tastiera**—a dull, heavy sound that cannot be produced louder than *mezzo-forte* and must be bowed *flautando* (see below).
3. Playing with just the edge of the bow hairs, **flautando**—a delicate, flute-like tone that cannot be produced louder than *mezzo-forte.*
4. Playing exclusively near the grip end (**frog**) of the bow, **al tallone**—fierce, biting attacks and coarse tone, applicable to short notes and tremolos only.
5. Playing exclusively near the tip of the bow, **sulla punta d'arco**—delicate, tentative attacks and wispy tone, applicable to short notes and tremolos only.
6. Playing with the wooden part of the bow, **col legno**. The on-string and off-string versions of this are very distinct and are nowadays specified separately. In **col legno tratto** the bow is turned sideways and drawn across the strings so that both hair and wood are used; this produces a very coarse tone. In **col legno battuto**, the more usual kind, the bow is turned upside down and the wooden part alone is bounced on the strings, producing a distinct, woody click with each attack.

All these techniques are invoked with their Italian names and canceled with "nat.," "ord.," or "modo ord." With obvious exceptions, it is possible to use these devices in combination. All are quite traditional and have been in use since the seventeenth century.

Contemporary, non-traditional bowing effects include:

1. Bowing behind the bridge—four squeaks of indeterminate pitch.
2. Bowing the tailpiece of a cello or contrabass or the endpin of a cello. This produces a vaguely pitched, string-drum-like sound at about $B\flat_0$ on the cello and B_1 on the contrabass.
3. Bowing *behind* the fingers of the left hand (violin and viola must be held cello-fashion to do this). The sound is very thin and gamba-like, *pp* or *ppp*. The pitch is a function of the distance between the finger and the nut and is thus the inverse of the pitch produced on

the other side of the finger. Only the note an octave above the open string yields the same pitch on both sides of the finger.

4. **Underbowing**, i.e., the use of too little bow pressure to make the note speak. A *pp–ppp* hiss is produced, very slightly colored by the fingered pitch.
5. **Overbowing**, i.e., the use of too much bow pressure. This makes a very harsh grating or squawking sound, colored by the fingered pitch. Privileged-frequency "undertones" a fourth, octave and/or eleventh *below* the fingered pitch may be produced, but these are extremely difficult to control with any accuracy.

PIZZICATO

A traditional and widely used technique is the **pizzicato**, in which the strings are plucked rather than bowed. For any extensive or complicated pizzicato passage the bow is put aside (this takes about half a second), but individual pizzicato notes can be played while still holding the bow. Pizzicato and bowed notes can be alternated about as rapidly as eighth-notes at ♩ = 120, but this is very awkward.

Pizzicato is invoked with the instruction "pizz." and canceled with "arco."

Stopped pizzicato notes on the violin and viola decay with great rapidity; the open strings ring softly for a second or two. On the cello and contrabass, open strings ring for two to three seconds and stopped notes in the lowest octave of each string ring for one-half to one and a half seconds. Within these time limitations slurs and glissandos can be performed in pizzicato just as on the guitar.

Pizzicato can be played at great speed by alternating fingers or by plucking back and forth with one finger. Pizzicato chords are generally strummed, guitar-fashion, and should be provided with arrows or arrowed arpeggio-signs to indicate the direction of the strum. Cellists and contrabassists use the thumb for upward arpeggios, the index finger for downward ones. For extensive strummed passages a violinist or violist will hold the instrument guitar-fashion; back-and-forth strumming can then be done with the thumb and index finger held together. A passage of this sort (even on cello or contrabass) should be specifically marked "alla chitarra."

A pizzicato chord to be plucked simultaneously rather than strummed should be marked with a bracket, e.g.,  , and the instruction "non arp."

Pizzicato may be performed *sul ponticello* or *sul tasto* if desired, just as with bowed notes. For a particularly stinging attack, the string may be plucked with the fingernail rather than (as is usual) with the flesh of the finger. This effect provides a useful intermediary between the normal sound and that of the snapped pizzicato described below. If desired, it must be called for with the expression "coll'unghia."

Two specialized forms of pizzicato are in use. The **left-hand pizzicato**, indicated with a plus sign above the affected note, is plucked by any free left-hand finger—ideally but not necessarily as a pull-off from the previous note. The sound is rather thin and somewhat *ponticello*, but the main effect is one of informality, since left-hand plucking is often used by players to check their intonation while tuning up, and hence tends to carry this association.

Left-hand pizzicato can be used simultaneously with bowing on the same or another string. Cellists and contrabassists frequently use a subtle left-hand pizzicato to aid in the attack of a loud, low bowed note. Left-hand pizzicato with the fingernail is impossible, since players must keep the nails of the left hand very short.

The **snapped, vertical,** or **Bartók pizzicato** is performed by pulling the string vertically and letting it snap back against the fingerboard with a snapping or slapping sound. This effect does not work for very high notes or in *ppp*. It is notated with the symbol ♁ above the note. (Observe that the reverse of this symbol, ♀ , means "stopped by the (left) thumb"; the two must not be confused.)

As an unorthodox pizzicato effect a guitar-type flat pick may be used and the instrument played *alla chitarra*. **Hammering-on** is occasionally used (especially by cellists) to aid in the attack of a bowed note. By itself it is usable but very weak—*pp* or less—and tends to produce pitches from the portions of the string on *both sides* of the finger, though this can be suppressed. A louder hammered-on sound can be produced unorthodoxly by wearing thimbles on the fingers of the left hand.

CHORDS

Normally the members of the violin family are monophonic instruments, but chords of up to four notes (**double, triple,** and **quadruple stops**) can be played, subject to certain limitations. For the left hand the limitations on pitch choices can be derived easily from the charts of maximum stretches given above. All else being equal, the easiest multiple stops are those in which the lowest-numbered finger used stops the lowest-pitched string used, and so on up in order. Remember that any slur requires either lifting or depressing a finger, use of a previously unused string, or a shift of the hand. Because of the curved bridge, quadruple stops must be arpeggiated (the four notes cannot be sounded simultaneously) and it is usually impossible to sustain triple stops for any great length of time. The limitations are as follows: on violin and viola, triple stops can be fully sustained in *forte* or louder, or for an instant in *mezzo-forte*, but at softer dynamic levels triple stops must be arpeggiated; on cello, triple stops can be attacked simultaneously in *forte* or louder, but only two of the notes can be sustained; and on the contrabass all triple stops must be arpeggiated.

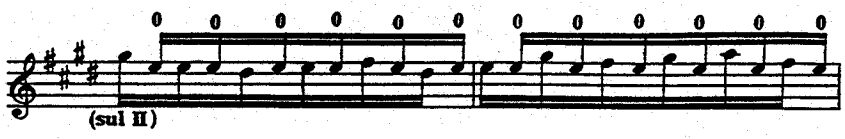
Triple and quadruple stops are frequently written as if they were to be fully sustained, but this is just a convention. The player will hit all the notes and then sustain only two (usually the top two) or, where possible on violin and viola, three. If one of the notes involved is an open string it will be allowed to vibrate and can still contribute to the chord even when it is no longer bowed. Where arpeggiation is necessary it will be performed very quickly, unless the arpeggiation sign, implying a more leisurely approach, is appended. Arpeggiation will be from bottom to top unless otherwise specified.

In orchestral writing, care must be taken to distinguish multiple stops from divided sections. The term "divisi" should be rigorously appended whenever a section is to be divided and "unis." used when it is to reunite, while multiple stops should be bracketed, e.g.,  , if there is any doubt as to their meaning.

Arpeggiated and broken chords of all kinds are whenever possible fingered in the left hand as if they were multiple stops, the different notes being articulated by moving the bow

from string to string. In writing passages of this type composers should always bear in mind the exigencies of the left hand and try to keep each separate *gruppetto* within the limits of what can be grasped by the left hand without moving.

Trills are usually performed in the obvious way, by repeatedly stopping and unstopping a note with one finger, but wide trills (often confusingly called "tremolos") can be performed with the bow by alternating strings. The rapid alternation of two strings, especially when used as a timbre effect, is known as **bariolage**. Frequently advantage is taken of the difference in timbre between stopped and open versions of the same pitch, as in this violin example from Bach:



Double stops on nonadjacent strings are possible by calling for—and explaining—either of two unorthodox techniques. The two outermost strings can be bowed simultaneously by turning the bow upside down and pressing it up against the strings from underneath. This technique is very difficult to control, requires considerable preparation time, and can only be performed slowly. A potentially much more useful technique that has, however, not yet (1984) been used in any composition is simply to push one of the middle strings down out of the way at the very end of the fingerboard and then bow the two strings adjoining it. The open strings and all natural harmonics that lie within reach of the other left-hand fingers may be played in this way, and by playing slightly *sul ponticello* one may play thus with one of the two strings stopped, even near the end of the fingerboard. In the region near the bridge where true *sul ponticello* is played, the pushed-down string rises up high enough to be bowed and the "disjunct" double-stop is not possible. On all members of the violin family except the cello it is possible to push down *both* middle strings and play on the outer two strings (open strings and natural harmonics only), *mezzo-piano* or softer.

TONE AND EXPRESSION

The four strings produce slightly different timbres, which composers occasionally exploit by specifying the string on which a given passage is to be played. The lowest string in particular yields a fuzzy, covered tone compared to the others. Strings may be named either by letter (violin: G, D, A, E—analogously for the others) or by Roman numerals, I designating the highest string. Passages to be played on a given string are marked "sul G" or "sul IV," etc. String numbers (without the "sul") are also used to clarify the fingering of unusual multiple stops and harmonics.

A distinct vibrato is ordinarily applied to every note long enough to bear it. The vibrato is created as on the guitar, by shaking the left hand so that the fingers stopping the strings rock back and forth, creating a slight waver in pitch. If it is not desired the instruction "senza vibr." must be used. Vibrato is not normally applied to harmonics or open strings, though it can be if desired. On an open string the vibrato is produced by placing a finger on the nut and shaking the hand as usual.

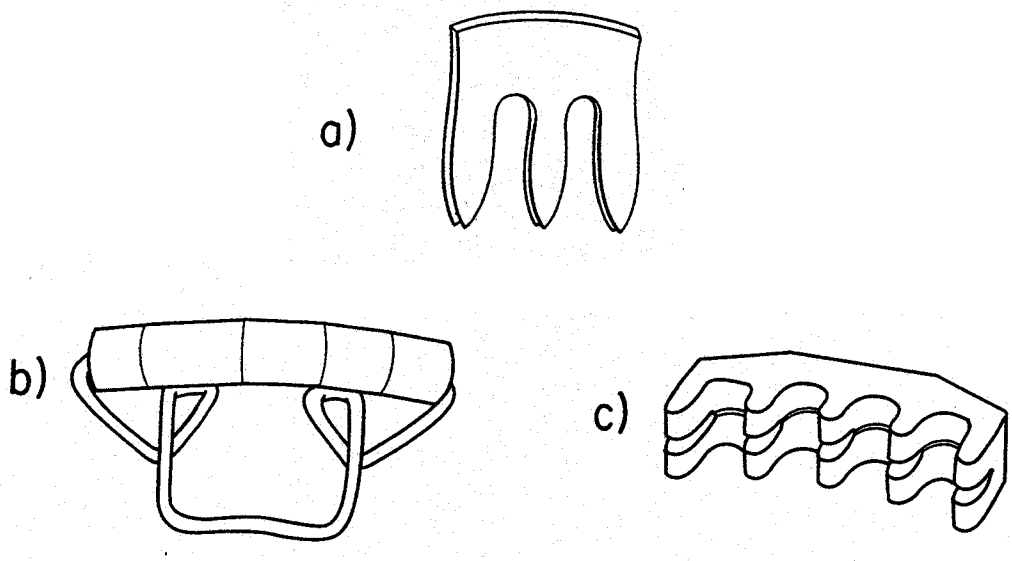


FIGURE 221. *Violin mutes: (a) traditional type; (b) newer style; (c) practice mute.*

Mutes are made for all members of the family. The ordinary mute exists in two forms. Both are slipped onto the top of the bridge, where they function by adding mass to the bridge and thus decreasing the efficiency with which it transmits vibrations to the soundboard. The older and still more common variety (Fig. 221a) is kept aside (on the music rack or in a vest pocket) when not in use, and requires about a second to be picked up and put in place, and another second when it is put aside. The newer variety (Fig. 221b) remains attached to the strings between bridge and tailpiece and can be slid up onto the bridge in less than half a second. The two types have the same effect.

The mute decreases the volume of the instrument only very slightly, but it makes the timbre gentle, velvety, and distant, as though the instrument were being played behind a closed door.

The **practice mute** (Fig. 221c) is essentially a heavy, metal version of the older type of ordinary mute. It reduces the maximum volume to *piano* and gives the instrument a tiny, thin, very distant sound.

On the violin family instruments, **harmonics** have the usual distant, denatured quality and low dynamic level. Limitations on natural harmonics are as follows.

Violin: possible on the e^2 string up to the sixth partial; on the a^1 string up to the seventh partial; on the d^1 string up to the eighth partial; on the g^0 string up to the ninth partial.

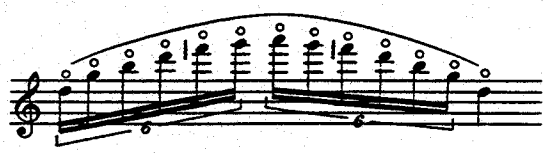
Viola: possible up to the ninth partial on all strings.

Cello: possible up to the twelfth partial on all strings. Nodes for partials above the sixth lie so close together that the player cannot reasonably be asked to pounce on any of them from far away.

Contrabass: possible on the G_0 string up to the sixteenth partial; on the D_0 and A_1 strings up to the fourteenth partial; and on the E_1 (or C_1) string up to the tenth partial. Nodes for partials above the eighth lie so close together that the player cannot reasonably be asked to pounce on any one of them from far away.

The high partials on any of the instruments are much more secure when played from nodes near the bridge rather than from equivalent nodes near the nut—unless the player has metal strings (instead of the usual wound gut), in which case it doesn't matter. Few players know or feel at ease with the "extra" nodes between the bridge series and the nut series (see Fig. 200).

A special effect (available on all members of the family and first exploited by Stravinsky) is the natural-harmonic "glissando" produced by sliding a finger down or up the string along the nodes of the bridge series or nut series of harmonics, usually starting with the third or fourth partial. The weak "extra" nodes in the middle do not speak during this progress, so a truly glissando-like curve of pitches is produced:

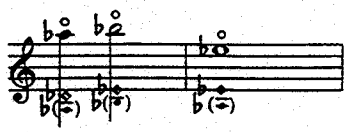


On cello and contrabass the pitch of a natural harmonic can be bent upward by "warping" the string sideways, guitar-fashion. On the cello the pitch may be raised as much as a quarter-step by this means, while on the contrabass harmonics can be raised an entire half-step.

Artificial harmonics are produced by stopping a string with one left-hand finger and touching the appropriate node with another finger of the same hand. On violin, viola, and cello the second to fifth partials are usable for artificial harmonics (subject, of course, to limitations of stretch—Fig. 220), though the fourth is by far the most frequently used. On the contrabass the third to sixth partials are available where the stopped note lies an octave or more above the pitch of the open string, but the third to eighth partials are available from stopped notes below that. On gut-strung contrabasses artificial harmonics are impossible when the stopped note lies less than a fifth above the pitch of the open string. On all the members of the family the upper pitch-limit for artificial harmonics is the same as that for ordinary stopped notes.

A natural harmonic should be notated as if it were an ordinary note, but with the usual little circle above it to indicate that it is a harmonic. Contrabass harmonics, like other notes, should be notated an octave above their sounding pitch. Bent harmonics require some sort of clarification.

Artificial harmonics are notated in a three-tiered system that gives the stopped note, the location of the node, and the resulting pitch on one stem with differently formed note-heads, thus:



An historically older and still more common practice reverses this notation, giving the stopped note with an ordinary note-head and the sounding pitch with a small, parenthetical

note-head unattached to the stem. The notation used here is to be preferred because it places the emphasis where it belongs—on the pitch produced.

Since instruments of the violin family have no frets, **microtones** are a simple matter in theory, but, particularly high in the range, they are often difficult to place accurately. The gap between quarter-tones is so narrow that on the violin adjacent quarter-tones cannot be played with adjacent fingers above first position but must be distinguished by rocking (not even sliding) one finger slightly forward or back. The same is true for the viola above third position. Nonadjacent quarter-tones are of course no problem in this respect. On contrabasses with low C_1 extension the quarter-tones below E_1 can be played by sticking the left hand into the machine and manipulating the C_1 string directly; this is of course very awkward and no kind of legato or glissando is possible.

Aside from this, all members of the family have almost unlimited possibilities of true glissando (see p. 31). Formerly, the normal practice was for any glissando that started or ended low in the range to cross strings, thus sounding somewhat discontinuous; today most players know to keep the whole glissando on one string if at all possible. Composers for their part should not write glissandos that exceed the range of an individual string. This one, for instance, is impossible:

Among contemporary special effects not mentioned so far are scraping a string lengthwise with bow or fingernails, possible on all strings except the violin's (unwound) top e^2; and tapping the body of the instrument with fingers, knuckles, or the wood of the bow.

Musical Examples

VIOLIN:

Ravel, *Tzigane*
Bartók, Sonata for solo violin
Messiaen, *Quatuor pour la fin du temps*

VIOLA:

Hindemith, *Kammermusik* No. 5
Boulez, *Le Marteau sans maître*
Feldman, *The Viola in My Life*

VIOLONCELLO:

Messiaen, *Quatuor pour la fin du temps*
Schoenberg, Cello Concerto (after Monn)
Xenakis, *Nomos alpha*

CONTRABASS:

Prokofiev, Quintet for winds and strings, Op. 39
Crumb, *Madrigals* (Books I, IV)
Chihara, *Logs*

STRING QUARTET:

Bartók, String Quartet No. 4
Cage, *String Quartet in Four Parts*
E. Brown, String Quartet
Crumb, *Black Angels*

Additional Examples

STRING ORCHESTRA:

Bartók, *Divertimento*
Chavez, Symphony No. 5
Xenakis, *Syrmos*

FULL ORCHESTRA:

Hindemith, *Symphonie Mathis der Maler*
Stravinsky, *Le Sacre du printemps*
Agon
Janáček, *Sinfonietta*
Bartók, *Bluebeard's Castle*
Webern, *Six Pieces*, Op. 6 (original version)
Messiaen, *Chronochromie*
Ligeti, *Atmosphères*